3447

TELEPHONE SUITS.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

BELL TELEPHONE COMPANY ET AL.

v.

PETER A. DOWD.

PART II.

EXHIBITS OF COMPLAINANTS AND DEFENDANT.

CHAUNCEY SMITH, J. J. STORROW AND C. E. HUBBARD,
for Complainants.

CAUSTEN BROWNE, GEORGE GIFFORD AND WM. D. BALDWIN,
for Defendant.

BOSTON:
ALFRED MUDGE & SON, LAW PRINTERS, 34 SCHOOL STREET.
1880.

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A. G. BELL.

TELEGRAPHY.

No. 174,465. Patented March 7, 1876.

Fig. 6.

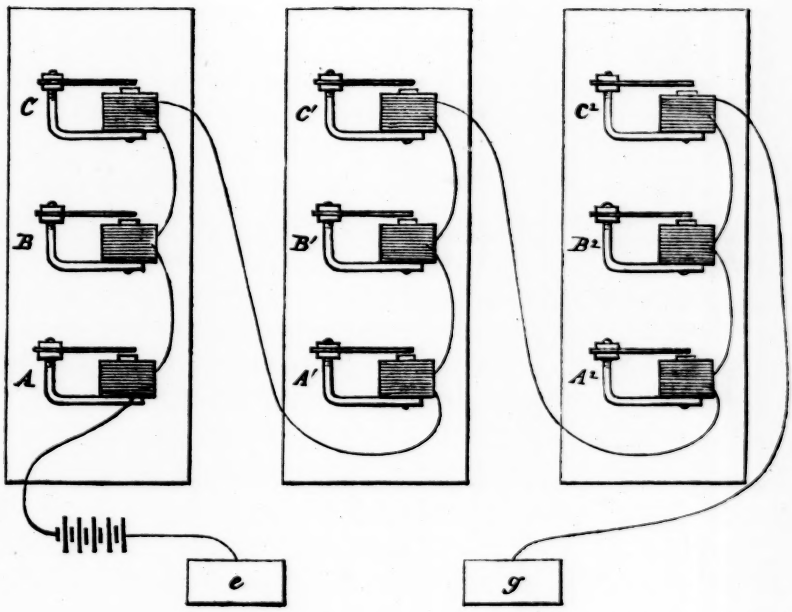
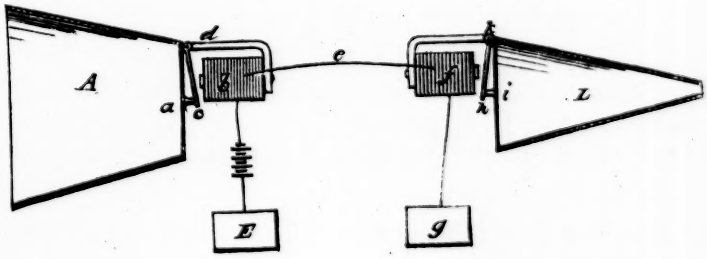


Fig. 7.



Witnesses:

Ewell Stock,

H. J. Hutchinson

Inventor:

A. Graham Bell

by Atty's Pollock & Bailey

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2 Sheets—Sheet 1.

A. G. BELL.

TELEGRAPHY.

No. 174,465. Patented March 7, 1876.

Fig. 1.

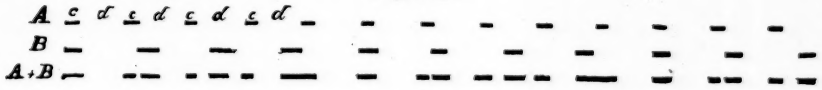

Fig. 2.

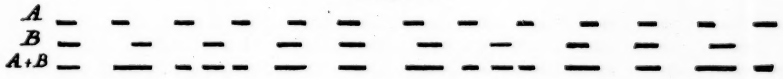

Fig. 3.

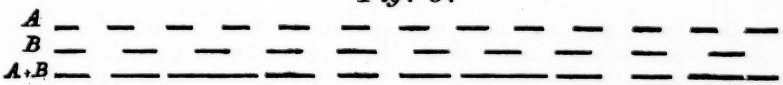

Fig. 4.

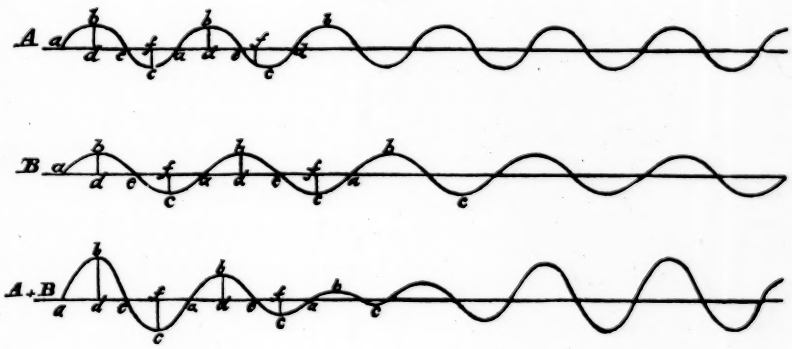

Fig. 5.

Witnesses:

Ewell Stock,

H. T. Hutchinson

Inventor:

A. Graham Bell

by atty. Pollock & Bailey

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COMPLAINANTS' EXHIBITS.

COMPLAINANTS' EXHIBIT 1, W. P. PREBLE, JR., EXAMINER.

[See Page 17]

IMPROVEMENT IN TELEGRAPHY.

UNITED STATES PATENT OFFICE.

Alexander Graham Bell, of Salem, Massachusetts.

Specification forming part of Letters Patent No. 174,465, dated March 7, 1876; application filed Feb. 14, 1877.

To all whom it may concern:

Be it known that I, Alexander Graham Bell, of Salem, Massachusetts, have invented certain new and useful Improvements in Telegraphy, of which the following is a specification: —

In Letters Patent granted to me April 6, 1875, No. 161,739, I have described a method of, and apparatus for, transmitting two or more telegraphic signals simultaneously along a single wire by the employment of transmitting-instruments, each of which occasions a succession of electrical impulses differing in rate from the others; and of receiving-instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting-instruments; and of vibratory circuit-breakers operating to convert the vibratory movement of the receiving-instrument into a permanent make or break (as the case may be) of a local circuit, in which is placed a Morse sounder, register or other telegraphic apparatus. I have also therein described a form of autograph-telegraph based upon the action of the above-mentioned instruments.

In illustration of my method of multiple telegraphy I have shown in the patent aforesaid, as one form of transmitting-instrument, an electro-magnet having a steel-spring armature, which is kept in

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vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent current upon the line-wire. I have found, however, that upon this plan the limit to the number of signals that can be sent simultaneously over the same wire is very speedily reached; for when a number of transmitting-instruments having different rates of vibration are simultaneously making and breaking the same circuit, the effect upon the main line is practically equivalent to one continuous current.

In a pending application for Letters Patent, filed in the United States Patent Office February 25, 1875, I have described two ways of producing the intermittent current — the one by actual make and break of contact, the other by alternately increasing and diminishing the intensity of the current without actually breaking the circuit. The current produced by the latter method I shall term, for distinction sake, a "pulsatory current."

My present invention consists in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of and apparatus for producing electrical undulations upon the line-wire.

The distinction between an undulatory and a pulsatory current will be understood by considering that electrical pulsations are caused by sudden or instantaneous changes of intensity, and that electrical undulations result from gradual changes of intensity exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations. The electrical movement, like the aerial motion, can be represented by a sinusoidal curve or by the resultant of several sinusoidal curves.

Intermittent or pulsatory and undulatory currents may be of two kinds, accordingly as the successive impulses have all the same polarity or are alternately positive and negative.

The advantages I claim to derive from the use of an undulatory current in place of a merely intermittent one are, first, that a very much larger number of signals can be transmitted simultaneously on the same circuit; second, that a closed circuit and single main battery may be used; third, that communication in both directions is established without the necessity of special induction coils; fourth,

that cable dispatches may be transmitted more rapidly than by means of an intermittent current or by the methods at present in use, for, as it is unnecessary to discharge the cable before a new signal can be made, the lagging of cable-signals is prevented; fifth, and that as the circuit is never broken a spark-arrester becomes unnecessary.

It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet a current of electricity is induced in the coils of the latter, and that when it is made to recede a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond, in rapidity of succession, to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration.

That the difference between an undulatory and an intermittent current may be more clearly understood, I shall describe the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously — first upon the one plan, and then upon the other. Let the interval between the two sounds be a major third, then their rates of vibration are in the ratio of 4 to 5. Now, when the intermittent current is used, the circuit is made and broken four times by one transmitting instrument in the same time that five makes and breaks are caused by the other. A and B, Figs. 1, 2 and 3, represent the intermittent currents produced, four impulses of B being made in the same time as five impulses of A. *c c c*, etc., show where and for how long time the circuit is made, and *d d d*, etc., indicate the duration of the breaks of the circuit. The line A and B shows the total effect upon the current when the transmitting instruments for A and B are caused simultaneously to make and break the same circuit. The resultant effect depends very much upon the duration of the make relatively to the break. In Fig. 1 the ratio is as 1 to 4; in Fig. 2, as 1 to 2, and in Fig. 3 the makes and breaks are of equal duration. The combined effect A and B, Fig. 3, is very nearly equivalent to a continuous current.

When many transmitting instruments of different rates of vibration are simultaneously making and breaking the same circuit the

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current upon the main line becomes for all practical purposes continuous.

Next, consider the effect when an undulatory current is employed. Electrical undulations, induced by the vibration of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself and the effect of its vibration upon the air; for, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body — that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration — that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body — that is, to the condensations and rarefactions of air produced by the vibration. Hence, the sinusoidal curve A or B, Fig. 4, represents graphically the electrical undulations induced in a circuit by the vibration of a body capable of inductive action.

The horizontal line *a d e f*, etc., represents the zero of current. The elevations *b b b*, etc., indicate impulses of positive electricity. The depressions *c c c*, etc., show impulses of negative electricity. The vertical distance *b d* or *c f* of any portion of the curve from the zero-line expresses the intensity of the positive or negative impulse at the part observed, and the horizontal distance *a a* indicates the duration of the electrical oscillation. The vibrations represented by the sinusoidal curves B and A, Fig. 4, are in the ratio aforesaid, of 4 to 5 — that is, four oscillations of B are made in the same time as five oscillations of A.

The combined effect of A and B, when induced simultaneously on the same circuit, is expressed by the curve A × B, Fig. 4, which is the algebraical sum of the sinusoidal curves A and B. This curve A × B also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously. Thus, when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing bodies. Hence, the coexistence upon a telegraphic circuit of electrical vibrations of different pitch is manifested, not by the obliteration of the vibratory

character of the current, but by peculiarities in the shapes of the electrical undulations, or, in other words, by peculiarities in the shapes of the curves which represent those undulations.

There are many ways of producing undulatory currents of electricity, dependent for effect upon the vibrations or motions of bodies capable of inductive action. A few of the methods that may be employed I shall here specify. When a wire through which a continuous current of electricity is passing is caused to vibrate in the neighborhood of another wire, an undulatory current of electricity is induced in the latter. When a cylinder upon which are arranged bar-magnets is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet.

Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration of the conducting-wire itself in the neighborhood of such bodies. Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery. The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them farther apart. The reciprocal vibration of the elements of a battery, therefore, occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance, let mercury or some other liquid form part of a voltaic circuit, then the more deeply the conducting wire is immersed in the mercury or other liquid the less resistance does the liquid offer to the passage of the current. Hence, the vibration of the conducting wire in mercury or other liquid included in the circuit occasions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which they are immersed produces an undulatory action in the current by alternately increasing and diminishing the power of the battery.

In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose an electro-magnet, A, Fig. 5, having a coil upon only one of its legs *b*. A steel-spring

armature *c* is firmly clamped by one extremity to the uncovered leg *d* of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature *c* can be set in vibration in a variety of ways, one of which is by wind, and in vibrating it produces a musical note of a certain definite pitch.

When the instrument A is placed in a voltaic circuit, *g b e f g*, the armature *c* becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature *c* remains at rest, no effect is produced upon the voltaic current; but the moment it is set in vibration to produce its musical note, a powerful inductive action takes place, and electrical undulations traverse the circuit *g b e f g*. The vibratory current passing through the coil of the electro-magnet *f* causes vibration in its armature *h* when the armatures *c h* of the two instruments A I are normally in unison with one another; but the armature *h* is unaffected by the passage of the undulatory current when the pitches of the two instruments are different.

A number of instruments may be placed upon a telegraphic circuit, as in Fig. 6. When the armature of any one of the instruments is set in vibration all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration remain silent. Thus if A, Fig. 6, is set in vibration, the armatures of A^1 and A^2 will vibrate also, but all the others on the circuit will remain still. So if B^1 is caused to emit its musical note, the instruments B B^2 respond. They continue sounding so long as the mechanical vibration of B^1 is continued but become silent with the cessation of its motion. The duration of the sound may be used to indicate the dot or dash of the Morse alphabet, and thus a telegraphic dispatch may be indicated by alternately interrupting and renewing the sound. When two or more instruments of different pitch are simultaneously caused to vibrate all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to that one only of the transmitting-instruments with which it is in unison. Thus the signals of A, Fig. 6, are repeated by A^1 and A^2, but by no other instrument upon the circuit; the signals of B^2 by B and B^1, and the signals of C^1 by C and B^2 — whether A, B^2, and C^1 are successively or simultaneously

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caused to vibrate. Hence by these instruments two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

When the armature *c*, Fig. 5, is set in vibration, the armature *h* responds not only in pitch but in loudness. Thus, when *c* vibrates with little amplitude, a very soft musical note proceeds from *h*; and when *c* vibrates forcibly, the amplitude of the vibration of *h* is considerably increased, and the resulting sound becomes louder. So, if A and B, Fig. 6, are sounded simultaneously (A loudly and B softly), the instruments A^1 and A^2 repeat loudly the signals of A, and B^1 B^2 repeat softly those of B.

One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument.

The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane, *a*. A cone, A, is used to converge sound-vibrations upon the membrane. When a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E *b e f g*. These undulations are similar in form to the air vibrations caused by the sound — that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L.

In this specification the three words "oscillation," "vibration," and "undulation" are used synonymously, and in contradistinction to the terms "intermittent" and "pulsatory." By the term "body capable of inductive action," I mean a body which, when in motion, produces dynamical electricity. I include in the category of bodies

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capable of inductive action, brass, copper, and other metals, as well as iron and steel.

Having described my invention, what I claim and desire to secure by Letters Patent, is as follows: —

1. A system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity, substantially as set forth.

2. The combination, substantially as set forth, of a permanent magnet or other body capable of inductive action, with a closed circuit, so that the vibration of the one shall occasion electrical undulations in the other, or in itself, and this I claim whether the permanent magnet be set in vibration in the neighborhood of the conducting-wire forming the circuit, or whether the conducting-wire be set in vibration in the neighborhood of the permanent magnet, or whether the conducting wire and the permanent magnet both simultaneously be set in vibration in each other's neighborhood.

3. The method of producing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of the conducting-wire itself in the neighborhood of such bodies as set forth.

4. The method of producing undulations in a continuous voltaic circuit by gradually increasing and diminishing the resistance of the circuit, or by gradually increasing and diminishing the power of the battery, as set forth.

5. The method of and apparatus for transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth.

In testimony whereof I have hereunto signed my name this 20th day of January, A. D. 1876.

ALEX. GRAHAM BELL.

Witnesses:

THOMAS E. BARRY,
P. D. RICHARDS.

2 Sheets—Sheet 1.

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A. G. BELL.

ELECTRIC TELEGRAPHY.

No. 186,787. Patented Jan. 30, 1877.

Fig. 1.

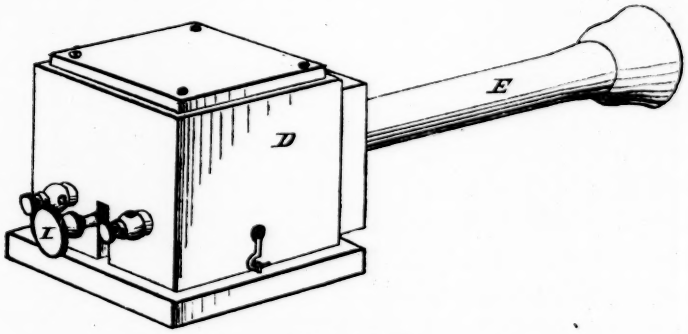


Fig. 2.

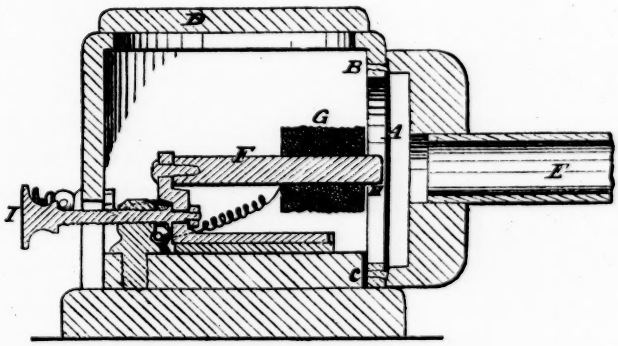
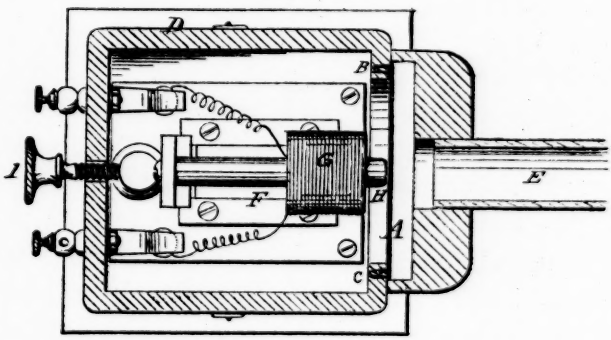


Fig. 3.



Attest

A. Pollok
Emil A. Stick.

Inventor

Alexander Graham Bell

3431

2 Sheets—Sheet 2.

A. G. BELL.

ELECTRIC TELEGRAPHY.

No. 186,787. Patented Jan. 30, 1877.

Fig. 4.

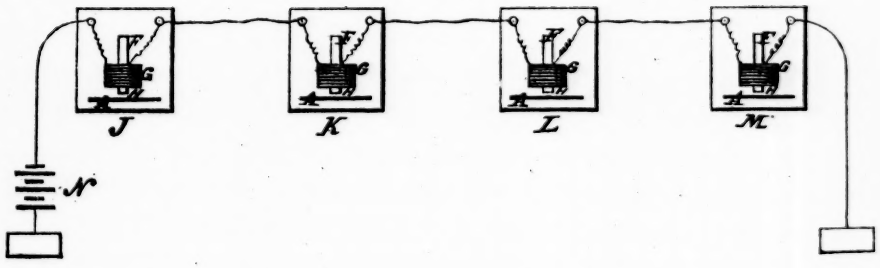


Fig. 5.

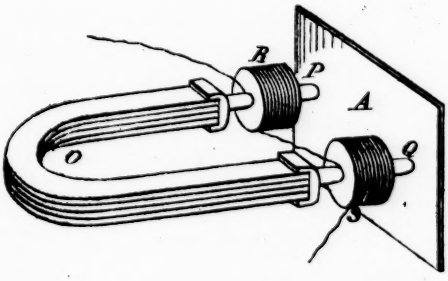
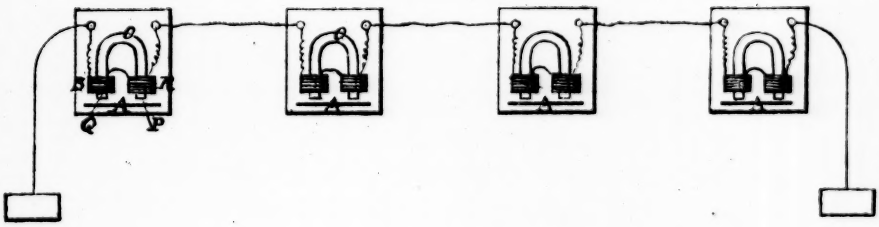


Fig. 6.



Attest:

A. Pollok
Everett Sick.

Inventor:

Alexander Graham Bell

COMPLAINANTS' EXHIBIT 2, W. P. PREBLE, JR., EXAMINER.

[See Page 17.]

UNITED STATES PATENT OFFICE.

Alexander Graham Bell, of Boston, Massachusetts.

IMPROVEMENT IN ELECTRIC TELEGRAPHY.

Specification forming part of Letters Patent No. 186,787, dated January 30, 1877; application filed January 15, 1877.

To all whom it may concern:

Be it known that I, Alexander Graham Bell, of Boston, Massachusetts, have invented certain new and useful Improvements in Electric Telephony, of which the following is a specification: —

In Letters Patent granted to me on the 6th day of April, 1875, No. 161,739, and in an application for Letters Patent of the United States now pending, I have described a method of and apparatus for producing musical tones by the action of a rapidly interrupted electrical current, whereby a number of telegraphic signals can be sent simultaneously along a single circuit.

In another application for Letters Patent now pending in the United States Patent Office, I have described a method of and apparatus for inducing an intermittent current of electricity upon a line-wire, whereby musical tones can be produced and a number of telegraphic signals be sent simultaneously over the same circuit, in either or in both directions; and in Letters Patent granted to me March 7, 1876, No. 174,465, I have shown and described a method of an apparatus for producing musical tones by the action of undulatory currents of electricity, whereby a number of telegraphic signals can be sent simultaneously over the same circuit, in either or in both directions, and a single battery be used for the whole circuit.

In the applications and patents above referred to, signals are transmitted simultaneously along a single wire by the employment

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of transmitting-instruments, each of which occasions a succession of electrical impulses differing in rate from the others, and are received without confusion by means of receiving-instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting-instruments. A separate instrument is therefore employed for every pitch, each instrument being capable of transmitting or receiving but a single note, and thus as many separate instruments are required as there are messages or musical notes to be transmitted.

My invention has for its object, first, the transmission simultaneously of two or more musical notes or telegraphic signals along a single wire, in either or both directions, and with a single battery for the whole circuit, without the use of as many instruments as there are musical notes or telegraphic signals to be transmitted; second, the electrical transmission by the same means of articulate speech, and sound of every kind, whether musical or not; third, the electrical transmission of musical tones, articulate speech, or sounds of every kind, without the necessity of using a voltaic battery.

In my patent No. 174,465, dated March 7, 1876, I have shown as one form of transmitting-instrument a stretched membrane to which the armature of an electro-magnet is attached, whereby motion can be imparted to the armature by the human voice, or by means of a musical instrument, or by sounds produced in any way.

In accordance with my present invention I substitute for the membrane and armature shown in the transmitting and receiving instruments alluded to above a plate of iron or steel capable of being thrown into vibration by sounds made in its neighborhood.

The nature of my invention and the manner in which the same is or may be carried into effect will be understood by reference to the accompanying drawings, in which —

Figure 1 is a perspective view of one form of my electric telephone. Fig. 2 is a vertical section of the same, and Fig. 3 is a plan view of the apparatus. Fig. 4 is a diagram illustrating the arrangement upon circuit.

Similar letters in the drawings represent corresponding portions of the apparatus.

A in said drawings represents a plate of iron or steel, which is fastened at B and C to the cover or sounding-box D. E represents a speaking-tube, by which sounds may be conveyed to or from the plate A. F is a bar of soft iron. G is a coil of insulated copper wire, placed around the extremity of the end H of the bar F. I is an adjusting-screw, whereby the distance of the end H from the plate A may be regulated.

The electric telephones, J, K, L and M, are placed at different stations upon a line, and are arranged upon circuit with a battery, N, as shown in diagram, Fig. 4.

I have shown the apparatus in one of its simplest forms, it being well understood that the same may be varied in arrangement, combination, general construction and form, as well as material of which the several parts are composed.

The operation and use of this instrument are as follows: —

I would premise by saying that this instrument is and may be used both as a transmitter and as a receiver — that is to say, the sender of the message will use an instrument in every particular indentical in construction and operation with that employed by the receiver, so that the same instrument can be used alternately as a receiver and a transmitter.

In order to transmit a telegraphic message by means of these instruments, it is only necessary for the operator at a telephone (say J) to make a musical sound, in any way, in the neighborhood of the plate A, — for convenience of operation, through the speaking-tube E, — and to let the duration of the sound signify the dot or dash of the Morse alphabet, and for the operator who receives his message (say at M) to listen to his telephone, preferably through the speaking-tube E. When two or more musical signals are being transmitted over the same circuit, all the telephones reproduce the signals for all the messages; but as the signals for each message differ in pitch from those for the other messages, it is easy for an operator to fix his attention upon one message and ignore the others.

When a large number of despatches are being simultaneously transmitted, it will be advisable for the operator to listen to his telephone through a resonator, which will re-enforce to his ear the

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signals which he desires to observe. In this way he is enabled to direct his attention to the signals for any given message without being distracted or disturbed by the signals for any other messages that may be passing over the line at the time.

The musical signals, if preferred, can be automatically received by means of a resonator, one end of which is closed by a membrane, which vibrates only when the note with which the resonator is in unison is emitted by the receiving-telephone. The vibrations of the membrane may be made to operate a circuit-breaker, which will actuate a Morse sounder or a telegraphic recording or registering apparatus.

One form of vibratory circuit-breaker which may be used for this purpose I have described in Letters Patent No. 178,399, June 6, 1876. Hence, by this plan the simultaneous transmission of a number of telegraphic messages over a single circuit in the same or in both directions, with a single main battery for the whole circuit and a single telephone at each station, is rendered practicable. This is of great advantage in this: that for the conveyance of several messages, or signals, or sounds over a single wire simultaneously, it is no longer necessary to have separate instruments correspondingly tuned for each given sound, which plan requires nice adjustment of the corresponding instruments, while the present improvement admits of a single instrument at each station; or if, for convenience, several are employed, they all are alike in construction, and need not be adjusted or tuned to particular pitches.

Whatever sound is made in the neighborhood of any telephone — say at J, Fig. 4 — is echoed in fac-simile by the telephones of all the other stations upon the circuit; hence this plan is also adapted for the use of the transmitting intelligibly the exact sounds of articulate speech. To convey an articulate message it is only necessary for an operator to speak in the neighborhood of his telephone, preferable through the tube E, and for another operator at a distant station upon the same circuit to listen to the telephone at that station. If two persons speak simultaneously in the neighborhood of the same or different telephones, the utterances of the two speakers are reproduced simultaneously by all the other telephones on the same circuit; hence, by this plan, a number of vocal messages may be

transmitted simultaneously on the same circuit in either or both directions. All the effects noted above may be produced by the same instruments without a battery by rendering the central bar F H permanently magnetic. Another form of telephone, for use without a battery, is shown in Fig. 5, in which O is a compound permanent magnet, to the poles of which are affixed poll-pieces of soft iron, P Q, surrounded by helices of insulated wire, R S.

Fig. 6 illustrates the arrangement upon circuits of similar instruments to that shown in Fig. 5.

In lieu of the plate A in above figures, iron or steel reeds of definite pitch may be placed in front of the electro-magnet O, and, in connection with a series of such instruments of different pitches, an arrangement upon circuit may be employed similar to that shown in my patent No. 174,465, and illustrated in Fig. 6 of Sheet 2 in said patent. The battery, of course, may be omitted.

This invention is not limited to the use of iron or steel, but includes within its scope any material capable of inductive action.

The essential feature of the invention consists in the armature of the receiving instrument being vibrated by the varying attraction of the electro-magnet, so as to vibrate the air in vicinity thereof in the same manner as the air is vibrated at the other end by the production of the sound. It is therefore by no means necessary or essential that the transmitting-instrument should be of the same construction as the receiving instrument. Any instrument receiving and transmitting the impression of agitated air may be used as the transmitter, although for convenience, and for reciprocal communication, I prefer to use like instruments at either end of an electrical wire. I have heretofore described and exhibited such other means of transmitting sound, as will be seen by reference to the Proceedings of the American Academy of Arts and Sciences, Volume XII.

For convenience, I prefer to apply to each instrument a call-bell. This may be arranged so as to ring, first, when the main circuit is opened: second, when the bar F comes into contact with the plate A. The first is done to call attention; the second indicates when it is necessary to readjust the magnet, for it is important that the distance of the magnet from the plate should be as little as possible, without however, being in contact. I have also found that the

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electrical undulations produced upon the main line by the vibration of the plate A are intensified by placing the coil G at the end of the bar F nearest the plate A, and not extend it beyond the middle, or thereabout.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is —

1. The union upon and by means of an electric circuit of two or more instruments, constructed for operation substantially as herein shown and described, so that if motion of any kind or form be produced in any way in the armature of any one of the said instruments, the armatures of all the other instruments upon the same circuit will be moved in like manner and form, and if such motion be produced in the former by sound, like sound will be produced by the motion of the latter.

2. In a system of electric telegraphy or telephony, consisting of transmitting and receiving instruments united upon an electric circuit, the production, in the armature of each receiving-instrument, of any given motion by subjecting said armature to an attraction varying in intensity, however such variation may be produced in the magnet; and hence I claim the production of any given sound or sounds from the armature of the receiving instrument by subjecting said armature to an attraction varying in intensity, in such manner as to throw the armature into that form of vibration that characterizes the given sound or sounds.

3. The combination, with an electro-magnet, of a plate of iron or steel, or other material capable of inductive action, which can be thrown into vibration by the movement of surrounding air or by the attraction of a magnet.

4. In combination with a plate and electro-magnet, as before claimed, the means herein described, or their mechanical equivalents, of adjusting the relative position of the two so that, without touching, they may be set as closely together as possible.

5. The formation, in an electric telephone such as herein shown and described, of a magnet with a coil upon the end or ends of the magnet nearest the plate.

6. The combination, with an electric telephone such as described, of a sounding-box, substantially as herein shown and set forth.

7. In combination with an electric telephone, as herein described, the employment of a speaking or hearing tube for conveying sounds to or from the telephone, substantially as set forth.

8. In a system of electric telephony, the combination of a permanent magnet with a plate of iron or steel, or other material capable of inductive action, with coils upon the end or ends of said magnet nearest the plate, substantially as set forth.

In testimony whereof I have hereunto signed my name this 13th day of January, A. D. 1877.

A. GRAHAM BELL.

Witnesses:

HENRY R. ELLIOTT,
EWELL A. DICK.

COMPLAINANTS' EXHIBIT 3, W. P. PREBLE, JR., EXAMINER.

[SEE PAGE 17.]

ASSIGNMENT OF PATENT RIGHT.

Liber R. 21, p. 399.

To all whom it may concern:

Whereas, Alexander Graham Bell, of Boston, in the county of Suffolk and State of Massachusetts, did obtain three several Letters Patent of the United States, for an improved system of telegraphy, telephony and telephonic apparatus, which Letters Patent bear date respectively, March seventh, A. D. eighteen hundred and seventy-six, and numbered 174,465, June sixth, A. D. eighteen hundred and seventy-six, and numbered 178,399, and January thirtieth, A. D. eighteen hundred and seventy-seven, and numbered 186,787.

And whereas, Gardiner G. Hubbard, of Cambridge, in the county of Middlesex and State of Massachusetts, trustee, is desirous of acquiring an interest therein, now this indenture witnesseth, that for a valuable consideration, viz.: one dollar and other valuable consideration to me in hand paid, the receipt of which is hereby acknowledged, I have assigned, sold and set over, and by these presents

do assign, sell and set over unto the said Gardner G. Hubbard, trustee, all the right, title and interest I have in the above described invention, as secured to me by Letters Patent, for, to and in the United States and Territories, and in no other place or places. The same to be held and enjoyed by the said Gardiner G. Hubbard, trustee, for his own use and behoof, and for the use and behoof of his legal representatives, to the full end of the term for which said Letters were granted, as fully and entirely as the same would have been held and enjoyed by me, had this assignment and sale not been made.

In testimony whereof I have hereunto set my hand and affixed my seal this day of July, in the year of our Lord one thousand eight hundred and seventy-seven.

ALEXANDER GRAHAM BELL. [SEAL]

Sealed and delivered in presence of
CHARLES EUSTIS HUBBARD.

Recorded July 28, 1877.
Ex'd E. A. M., M. McK.

COMPLAINANTS' EXHIBIT 4, W. P. PREBLE, JR., EXAMINER.

[SEE PAGE 17.]

ASSIGNMENT OF PATENT RIGHT.

Liber Y 22, page 460.

To all whom it may concern:

Whereas, Alexander Graham Bell, of Salem, Massachusetts, as assignor to himself, Thomas Sanders and Gardiner G. Hubbard, did obtain Letters Patent of the United States, bearing date April 6th, 1875, and numbered 161,739. And whereas, said Alex. Graham Bell did obtain Letters Patent of the United States, bearing date March 7th, 1876, and numbered 174,465; bearing date June 6th, 1878, and numbered 178,399; and bearing date January 30th, 1877, and numbered 186,787, all of said Letters Patent being for improvements in "telegraphy, telephony and telephonic apparatus," in-

vented by said Alexander Graham Bell. And whereas, all of said Letters Patent have been assigned to Gardiner G. Hubbard, trustee, said Letters numbered 161,739, by deed of assignment delivered July 9th, 1877, and recorded in Liber T 21, page 448, of Transfers of Patents, and said Letters numbered 174,465, 178,399 and 186,787, by deed of assignment delivered July 9th, 1877, and recorded in Liber R 21, page 399, of Transfers of Patents, and said Hubbard, trustee, is now the owner of the above described inventions, secured by said Letters Patents. And whereas, the Bell Telephone Company, a corporation duly established under the laws of the commonwealth of Massachusetts, and located at Boston, is desirous of acquiring the ownership of said inventions secured by said Letters Patent:

Now, this indenture witnesseth, that I, Gardiner G. Hubbard, trustee, in consideration of one dollar and other valuable consideration to me in hand paid by said Bell Telephone Company, the receipt whereof is hereby acknowledged, have assigned, sold and set over, and by these presents do assign, sell and set over unto the said Bell Telephone Company, all my right, title and interest in the above described inventions and in and to said Letters Patent, each and all of them, the same to be held and enjoyed by the said Bell Telephone Company for its own use and behoof, and for the use and behoof of its legal representatives to the full end of the term for which said Letters were granted, and any extension or reissue thereof, as fully and entirely as the same would have been held and enjoyed by me had this assignment and sale not been made.

In testimony whereof I have hereunto set my hand and seal this twentieth day of July, in the year eighteen hundred and seventy-eight, being thereto duly authorized.

[SEAL] GARDINER G. HUBBARD, *Trustee.*

In presence of

C. E. HUBBARD.

R. W. DEVONSHIRE.

Recorded Oct. 3d, 1878.

Ex. J. A. W., M. McK.

COMPLAINANTS' EXHIBIT 5, W. P. PREBLE, JR., EXAMINER.

Know all men by these presents: —

That whereas, Gardiner G. Hubbard, of Cambridge, Massachusetts, as Trustee for the Bell Telephone Company, under a declaration of trust dated July 9, 1877, owns the following patents of the United States: —

No. 161,739, dated April 6, 1875, granted to Alexander Graham Bell, assignor to himself and Thomas Sanders and Gardiner G. Hubbard, for "Improvement in Transmitters and Receivers for Electric Telegraph";

No. 174,465, dated March 7, 1876, to Alexander Graham Bell, for "Improvement in Telegraphy";

No. 178,399, dated June 6, 1876, to Alexander Graham Bell, for "Improvement in Telephonic Telegraph Receivers," and No. 186,787, dated Jan. 30, 1877, to Alexander Graham Bell, for "Improvement in Electric Telegraphy";

And the inventions therein described, or intended so to be; and expects also to acquire the right to use other inventions and improvements relating to telephony and telephonic apparatus;

And whereas, the New England Telephone Company has been organized for the purpose of carrying on the business of manufacturing and renting telephones and constructing lines of telegraph therefor, in the New England States;

Now, therefore, the said Gardiner G. Hubbard, Trustee, in consideration of one dollar, and other valuable consideration, to him paid by said New England Telephone Company, hereby conveys, and will convey to said New England Telephone Company the following interest, or so much of the same as he now, or at any time hereafter may own, or have power to convey, acting as trustee, as aforesaid, to wit: —

The full, free and exclusive license to use, and to license others to use said inventions, and all patents issued or to be issued thereon, and all reissues and extensions thereof, and a license to make the patented articles, to be used only in the New England States, to wit, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island

and Connecticut, together with all other rights and privileges which said Hubbard, or his successors in said trust, or said Bell Telephone Company, or its successors may own, control or have the power to grant, so far as may be needed to enable said New England Telephone Company, its successors and assigns, to enjoy said granted right within said territory, as freely, fully and beneficially as said Hubbard, or said Bell Telephone Company, or his or its successors could have done had this conveyance not been made.

In witness whereof, I, the said Gardiner G. Hubbard, trustee, thereto duly authorized, have hereunto set my hand seal this second day of February, 1876.

GARDINER G. HUBBARD,
Trustee.

Witnesses:

R. W. DEVONSHIRE.
G. V. LADD.

Received for record Oct. 29, 1878, and recorded in Liber Q-23, page 5 of Transfers of Patents.

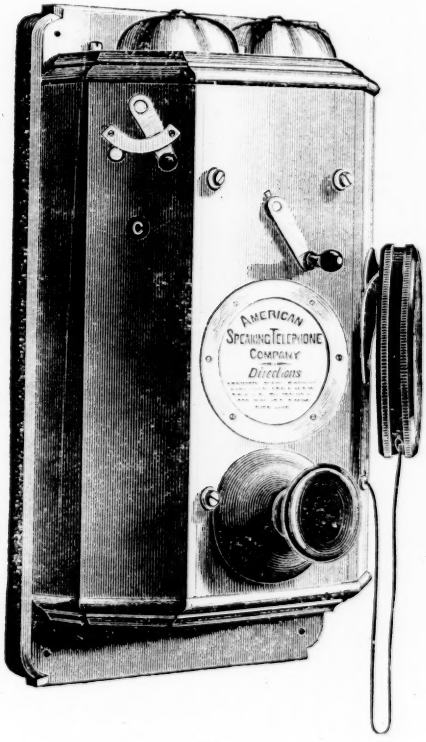
In testimony whereof, I have caused the seal of the Patent Office to be hereunto affixed.

[SEAL] W. H. DOOLITTLE,
Acting Commissioner.

Exd. F. C. T.

COMPLAINANTS' EXHIBIT No. 6, PHELPS' BOX TELEPHONE.

(Record, Page 18.)



(1)

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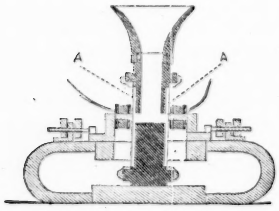
COMPLAINANTS' EXHIBIT NO. 6, PHELPS' BOX TELEPHONE. (Sectional View.)

(RECORD, PAGE 18.)



A A Metallic Diaphragms.

Extreme diameter of permanent magnet .	7	inches.
Diameter of spool	$\frac{7}{8}$	"
Diameter of diaphragm	$2\frac{3}{4}$	"
Length of spool	$\frac{3}{8}$	"
Total length of speaking tube . . .	$3\frac{1}{2}$	"

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COMPLAINANTS' EXHIBIT No. 7, PHELPS' DUPLEX TELEPHONE.

(Record, Page 18.)

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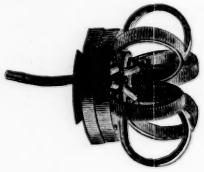
COMPLAINANTS' EXHIBIT NO. 8, PHELPS' CROWN TELEPHONE.

(RECORD, PAGE 18.)



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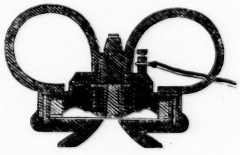
COMPLAINANTS' EXHIBIT NO. 8, PHELPS' CROWN TELEPHONE. (Sectional View.)

(RECORD, PAGE 18.)



DIMENSIONS.

Extreme diameter	5	inches.
Diameter of membrane	3	"
Diameter of spool	1	"
Diameter of core	$\frac{7}{16}$	"
Diameter of large end of mouth-piece	2	"
Diameter of small end of mouth-piece	$\frac{1}{2}$	"

COMPLAINANTS' EXHIBIT 9, W. C. W., EX'R.

[SEE PAGE 137.]

PROCEEDINGS
OF THE
AMERICAN ACADEMY
OF
ARTS AND SCIENCES.
VOL. XII.
PAPERS READ BEFORE THE ACADEMY.

I.

RESEARCHES IN TELEPHONY.

By A. GRAHAM BELL.

Presented May 10, 1876, by the Corresponding Secretary.

1. It has long been known that an electro-magnet gives forth a decided sound when it is suddenly magnetized or demagnetized. When the circuit upon which it is placed is rapidly made and broken, a succession of explosive noises proceeds from the magnet. These sounds produce upon the ear the effect of a musical note, when the current is interrupted a sufficient number of times per second. The discovery of "Galvanic Music," by Page,* in 1837, led inquirers in different parts of the world almost simultaneously to enter into the field of telephonic research; and the acoustical effects produced by magnetization were carefully studied by Marrian,† Beatson,‡ Gassiot,§ De la Rive,‖ Matteucci,¶ Guillemin,** Wertheim,†† Wart-

* *C. G. Page.* "The Production of Galvanic Music." Silliman's Journ., 1837, XXXII., p. 396; Silliman's Journ., July, 1837, p. 354; Silliman's Journ., 1838, XXXIII., p. 118; Bibl. Univ. (new series), 1839, II., p. 398.

† *J. P. Marrian.* Phil. Mag., XXV., p. 382; Inst., 1845, p. 20; Arch. de l'Électr., V., p. 195.

‡ *W. Beatson.* Arch. de l'Électr., V., p. 197; Arch. de Sc. Phys. et Nat. (2d series), II., p. 113.

§ *Gassiot.* See "Treatise on Electricity," by De la Rive, I., p. 300.

‖ *De la Rive.* Treatise on Electricity, I., p. 300; Phil. Mag., XXXV., p. 422; Arch. de l'Électr., V., p. 200; Inst., 1846, p. 83; Comptes Rendus, XX., p. 1287; Comp. Rend., XXII., p. 432; Pogg. Ann., LXXVI., p. 637; Ann. de Chim. et de Phys., XXVI., p. 158.

¶ *Matteucci.* Inst., 1845, p. 315; Arch. de l'Électr., V., 389.

** *Guillemin.* Comp. Rend., XXII., p. 264; Inst., 1846, p. 30; Arch. d. Sc. Phys. (2d series), I., p. 191.

†† *G. Wertheim.* Comp. Rend., XXII., pp. 336, 544; Inst., 1846, pp. 65, 100; Pogg.

mann,* Janniar,† Joule,‡ Laborde,§ Legat,‖ Reis,¶ Poggendorff,** Du Moncel,†† Delezenne,‡‡ and others.§§

2. In the autumn of 1874 I discovered that the sounds emitted by an electro-magnet under the influence of a discontinuous current of electricity, are not due wholly to sudden changes in the magnetic condition of the iron core (as heretofore supposed), but that a portion of the effect results from vibrations in the insulated copper wires composing the coils. An electro-magnet was arranged upon circuit with an instrument for interrupting the current, — the rheotome being placed in a distant room, so as to avoid interference with the experiment. Upon applying the ear to the magnet a musical note was clearly perceived, and the sound persisted after the iron core had been removed. It was then much feebler in intensity, but was otherwise unchanged, — the curious crackling noise accompanying the sound being well marked.

The effect may probably be explained by the attraction of the coils of the wire for one another during the passage of the galvanic current, and the sudden cessation of such attraction when the current is interrupted. When a spiral of fine wire is made to dip into a cup of mercury, so as thereby to close a galvanic circuit, it is well

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Ann., LXVIII., p. 140; Comp. Rend., XXVI., p. 505; Inst., 1848, p. 142; Ann. de Chim. et de Phys., XXIII., p. 302; Arch. d Sc. Phys. et Nat., VIII., p. 206; Pogg. Ann., LXXVII., p. 43; Berl. Ber., IV., p. 121.

* *Elie Wartmann.* Comp. Rend., XXII., p. 544; Phil. Mag. (3d series), XXVIII., p. 544; Arch. d. Sc. Phys. et Nat. (2d series), I., p. 419; Inst., 1846, p. 280; Monatscher, d. Berl. Akad., 1846, p. 111.

† *Janniar.* Comp. Rend., XXIII., p. 319; Inst., 1846, p. 269; Arch. d. Sc. Phys. et Nat. (2d series), II., p 394.

‡ *J. P. Joule.* Phil. Mag., XXV., pp. 76, 225; Berl. Ber., III., p. 489.

§ *Laborde.* Comp. Rend., L., p. 692; Cosmos, XVII., p. 514.

‖ *Legat.* Brix. Z. S., IX., p. 125.

¶ *Reis.* "Téléphonie," Polytechnic Journ., CLXVIII., p. 185; Böttger's Notizbl., 18 3, No. 6.

** *J. C. Poggendorff.* Pogg. Ann., XCVIII., p. 192; Berliner Monatsber., 1856, p. 133; Cosmos, IX., p. 49; Berl. Ber., XII., p. 241; Pogg. Ann., LXXXVII., p. 139.

†† *Du Moncel.* Exposé, II., p. 125; also III., p. 83.

‡‡ *Delezenne.* "Sound produced by Magnetization," Bibl. Univ. (new series), 1841, XVI., p. 406.

§§ See London Journ., XXXII., p. 402; Polytechnic Journ., CX., p. 16; Cosmos, IV., p 43; Glösener —— Traité général, &c., p. 350; Dove.-Repert., VI., p. 58; Pogg. Ann., XLIII., p. 411; Berl. Ber., I., p. 144; Arch. d. Sc. Phys. et Nat., XVI., p. 406; Kuhn's Encyclopædia der Physik, pp. 1014–1021.

known that the spiral coils up and shortens. Ferguson* constructed a rheotome upon this principle. The shortening of the spiral lifted the end of the wire out of the mercury, thus opening the circuit, and the weight of the wire sufficed to bring the end down again, — so that the spiral was thrown into continuous vibration. I conceive that a somewhat similar motion is occasioned in a helix of wire by the passage of a discontinuous current, although further research has convinced me that other causes also conspire to produce the effect noted above. The extra currents occasioned by the induction of the voltaic current upon itself in the coils of the helix no doubt play an important part in the production of the sound, as very curious audible effects are produced by electrical impulses of high tension. It is probable, too, that a molecular vibration is occasioned in the conducting wire, as sounds are emitted by many substances when a discontinuous current is passed through them. Very distinct sounds proceed from straight pieces of iron, steel, retort-carbon, and plumbago. I believe that I have also obtained audible effects from thin platinum and German-silver wires, and from mercury contained in a narrow groove about four feet long. In these cases, however, the sounds were so faint and outside noises so loud that the experiments require verification. Well-marked sounds proceed from conductors of all kinds when formed into spirals or helices. I find that De la Rive had noticed the production of sound from iron and steel during the passage of an intermittent current, although he failed to obtain audible results from other substances. In order that such effects should be observed, extreme quietness is necessary. The rheotome itself is a great source of annoyance, as it always produces a sound of similar pitch to the one which it is desired to hear. It is absolutely requisite that it should be placed out of earshot of the observer, and at such a distance as to exclude the possibility of sounds being mechanically conducted along the wire.

3. Very striking audible effects can by produced upon a short circuit by means of two Grove elements. I had a helix of insulated copper-wire (No. 23) constructed, having a resistance of about

* *Ferguson.* Proceedings of Royal Scottish Soc. of Arts, April 9, 1866; Paper on "A New Current Interrupter."

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twelve ohms. It was placed in circuit with a rheotome which interrupted the current one hundred times per second. Upon placing the helix to my ear I could hear the unison of the note produced by the rheotome. The intensity of the sound was much increased by placing a wrought-iron nail inside the helix. In both these cases, a crackling effect accompanied the sound. When the nail was held in the fingers so that no portion of it touched the helix, the crackling effect disappeared, and a pure musical note resulted.

When the nail was placed inside the helix, between two cylindrical pieces of iron, a loud sound resulted that could be heard all over a large room. The nail seemed to vibrate bodily, striking the cylindrical pieces of metal alternately, and the iron cylinders themselves were violently agitated.

4. Loud sounds are emitted by pieces of iron and steel when subjected to the attraction of an electro-magnet which is placed in circuit with a rheotome. Under such circumstances, the armatures of Morse-sounders and Relays produce sonorous effects. I have succeeded in rendering the sounds audible to large audiences by interposing a tense membrane between the electro-magnet and its armature. The armature in this case consisted of a piece of clock-spring glued to the membrane. This form of apparatus I have found invaluable in all my experiments. The instrument was connected with a parlor organ, the reeds of which were so arranged as to open and close the circuit during their vibration. When the organ was played, the music was loudly reproduced by the telephonic receiver in a distant room. When chords were played upon the organ, the various notes composing the chords were emitted simultaneously by the armature of the receiver.

5. The simultaneous production of musical notes of different pitch by the electric current was foreseen by me as early as 1870, and demonstrated during the year 1873. Elisha Gray,* of Chicago, and Paul la Cour,† of Copenhagen, lay claim to the same discovery. The fact that sounds of different pitch can be simultaneously produced upon any part of a telegraphic circuit is of great practical importance; for the duration of a musical note can be made to

* *Elisha Gray.* Eng. Pat. Spec., No. 974. See "Engineer," March 26, 1875.

† *Paul la Cour.* Telegraphic Journal, Nov. 1, 1875.

signify the dot or dash of the Morse alphabet, and thus a number of telegraphic messages may be sent simultaneously over the same wire without confusion by making signals of a definite pitch for each message.

6. If the armature of an electro-magnet has a definite rate of oscillation of its own, it is thrown bodily into vibration when the interruptions of the current are timed to its movements. For instance, present an electro-magnet to the strings of a piano. It will be found that the string which is in unison with the rheotome included in the circuit will be thrown into vibration by the attraction of the magnet.

Helmholtz,* in his experiments upon the synthesis of vowel sounds, caused continuous vibration in tuning-forks which were used as the armatures of electro-magnets. One of the forks was employed as a rheotome. Platinum wires attached to the prongs dipped into mercury.

The intermittent current occasioned by the vibration of the fork traversed a circuit containing a number of electro-magnets, between the poles of which were placed tuning-forks, whose normal rates of vibration were multiples of that of the transmitting fork. All the forks were kept in continuous vibration by the passage of the interrupted current. By re-enforcing the tones of the forks in different degrees by means of resonators, Helmholtz succeeded in reproducing artificially certain vowel sounds.

I have caused intense vibration in a steel strip, one extremity of which was firmly clamped to the pole of a U-shaped electro-magnet, the free end overhanging the other pole. The amplitude of the vibration was greatest when the coil was removed from the leg of the magnet to which the armature was attached.

7. All the effects noted above result from rapid interruptions of a voltaic current, but sounds may be produced electrically in many other ways.

The Canon Goltoin de Coma † in 1785 observed that noises were emitted by iron rods placed in the open air during certain electrical conditions of the atmosphere; Beatson ‡ produced a sound from an

* *Helmholtz.* Die Zehre von dem Tonempfindungen.

† See "Treatise on Electricity," by De la Rive, I., p. 300. ‡ Ibid.

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iron wire by the discharge of a Leyden jar; Gore * obtained loud musical notes from mercury, accompanied by singularly beautiful crispations of the surface during the course of experiments in electrolysis; and Page † produced musical tones from Trevelyan's bars by the action of the galvanic current.

8. When an intermittent current is passed through the thick wires of a Ruhmkorff's coil, very curious audible effects are produced by the currents induced in the secondary wires. A rheotome was placed in circuit with the thick wires of a Ruhmkorff's coil, and the fine wires were connected with two strips of brass (A and B), insulated from one another by means of a sheet of paper. Upon placing the ear against one of the strips of brass, a sound was perceived like that described above as proceeding from an empty helix of wire during the passage of an intermittent voltaic current. A similar sound, only much more intense, was emitted by a tin foil condenser, when connected with the fine wires of the coil.

One of the strips of brass A (mentioned above) was held closely against the ear. A loud sound came from A whenever the slip B was touched with the other hand. It is doubtful, in all these cases, whether the sounds proceeded from the metals or from the imperfect conductors interposed between them. Further experiments seem to favor the latter supposition. The strips of brass, A and B, were held one in each hand. The induced currents occasioned a muscular tremor in the fingers. Upon placing my forefinger to my ear, a loud crackling noise was audible, seemingly proceeding from the finger itself. A friend who was present placed my finger to his ear, but heard nothing. I requested him to hold the strips, A and B, himself. He was then distinctly conscious of a noise (which I was unable to perceive) proceeding from his finger. In these cases, a portion of the induced currents passed through the head of the observer when he placed his ear against his own finger; and it is possible that the sound was occasioned by a vibration of the surfaces of the ear and finger in contact.

When two persons receive a shock from a Ruhmkorff's coil by

* *Gore.* Proceedings of Royal Society, XII., p. 217.

† *Page.* "Vibration of Trevelyan's Barsby the Galvanic Current," Silliman's Journal, 1850, IX., pp. 105–108.

clasping hands, each taking hold of one wire of the coil with the free hand, a sound proceeds from the clasped hands. The effect is not produced when the hands are moist. When either of the two touches the body of the other, a loud sound comes from the parts in contact. When the arm of one is placed against the arm of the other, the noise produced can be heard at a distance of several feet. In all these cases, a slight shock is experienced so long as the contact is preserved. The introduction of a piece of paper between the parts in contact does not materially interfere with the production of the sounds, while the unpleasant effects of the shock are avoided.

When a powerful current is passed through the body, a musical note can be perceived when the ear is closely applied to the arm of the person experimented upon. The sound seems to proceed from the muscles of the forearm, and from the biceps muscle. The musical note is the unison of the rheotome employed to interrupt the primary circuit. I failed to obtain audible effects in this way when the pitch of the rheotome was high. Elisha Gray * has also produced audible effects by the passage of induced electricity through the human body. A musical note is occasoned by the spark of a Ruhmkorff's coil when the primary circuit is made and broken sufficiently rapidly. When two rheotomes of different pitch are caused simultaneously to open and close the primary circuit, a double tone proceeds from the spark.

9. When a voltaic battery is common to two closed circuits, the current is divided between them. If one of the circuits is rapidly opened and closed, a pulsatory action of the current is occasioned upon the other.

All the audible effects resulting from the passage of an intermittent current can also be produced, though in less degree, by means of a pulsatory current.

10. When a permanent magnet is caused to vibrate in front of the pole of an electro-magnet, an undulatory or oscillatory current of electricity is induced in the coils of the electro-magnet, and sounds proceed from the armatures of other electro-magnets placed upon the circuit. The telephonic receiver referred to above (par. 4) was connected in circuit with a single-pole electro-magnet, no battery

* *Elisha Gray.* Eng. Pat. Spec., No. 2646. See "Engineer," Aug. 14, 1874.

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being used. A steel tuning-fork which had been previously magnetized was caused to vibrate in front of the pole of the electro-magnet. A musical note, similar in pitch to that produced by the tuning-fork, proceeded from the telephonic receiver in a distant room.

11. The effect was much increased when a battery was included in the circuit. In this case, the vibration of the permanent magnet threw the battery-current into waves. A similar effect was produced by the vibration of an unmagnetized tuning-fork in front of the electro-magnet. The vibration of a soft iron armature, or of a small piece of steel spring no larger than the pole of the electro-magnet in front of which it was placed, sufficed to produce audible effects in the distant room.

12. Two single-pole electro-magnets, each having a resistance of ten ohms, were arranged upon a circuit with a battery of five carbon elements. The total resistance of the circuit, exclusive of the battery, was about twenty-five ohms. A drum-head of gold-beater's skin, seven centimetres in diameter, was placed in front of each electro-magnet, and a circular piece of clock-spring, one centimetre in diameter, was glued to the middle of each membrane. The telephones so constructed were placed in different rooms. One was retained in the experimental room, and the other taken to the basement of an adjoining house.

Upon singing into the telephone, the tones of the voice were reproduced by the instrument in the distant room. When two persons sang simultaneously into the instrument, two notes were emitted simultaneously by the telephone in the other house. A friend was sent into the adjoining building to note the effect produced by articulate speech. I placed the membrane of the telephone near my mouth, and uttered the sentence, "Do you understand what I say?" Presently an answer was returned through the instrument in my hand. Articulate words proceeded from the clock-spring attached to the membrane, and I heard the sentence, "Yes; I understand you perfectly."

The articulation was somewhat muffled and indistinct, although in this case it was intelligible. Familiar quotations, such as, "To be, or not to be; that is the question." "A horse, a horse, my kingdom

for a horse." "What hath God wrought?" etc., were generally understood after a few repetitions. The effects were not sufficiently distinct to admit of sustained conversation through the wire. Indeed, as a general rule, the articulation was unintelligible, excepting when familiar sentences were employed. Occasionally, however, a sentence would come out with such startling distinctness as to render it difficult to beleive that the speaker was not close at hand. No sound was audible when the clock-spring was removed from the membrane.

The elementary sounds of the English language were uttered successively into one of the telephones and the effects noted at the other. Consonantal sounds, with the exception of L and M, were unrecognizable. Vowel-sounds in most cases were distinct. Diphthongal vowels, such as *a* (in ale), *o* (in old), *i* (in isle), *ow* (in now), *oy* (in boy), *oor* (in poor), *oor* (in door), *ere* (in here), *ere* (in there), were well marked.

Triphthongal vowels, such as *ire* (in fire), *our* (in flour), *ower* (in mower), *ayer* (in player), were also distinct. Of the elementary vowel-sounds, the most distinct were those which had the largest oral apertures. Such were *a* (in far), *aw* (in law), *a* (in man), and *e* (in men).

13. Electrical undulations can be produced directly in the voltaic current by vibrating the conducting wire in a liquid of high resistance included in the circuit.

The stem of a tuning-fork was connected with a wire leading to one of the telephones described in the preceding paragraph. While the tuning-fork was in vibration, the end of one of the prongs was dipped into water included in the circuit. A sound proceeded from the distant telephone. When two tuning-forks of different pitch were connected together, and simultaneously caused to vibrate in the water, two musical notes (the unisons respectively of those produced by the forks) were emitted simultaneously by the telephone.

A platinum wire attached to a stretched membrane, completed a voltaic circuit by dipping into water. Upon speaking to the membrane, articulate sounds proceeded from the telephone in the distant room. The sounds produced by the telephone became louder when dilute sulphuric acid, or a saturated solution of salt, was substituted

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for the water. Audible effects were also produced by the vibration of plumbago in mercury, in a solution of bichromate of potash, in salt and water, in dilute sulphuric acid, and in pure water.

14. Sullivan* discovered that a current of electricity is generated by the vibration of a wire composed partly of one metal and partly of another; and it is probable that electrical undulations were caused by the vibration. The current was produced so long as the wire emitted a musical note, but stopped immediately upon the cessation of the sound.

15. Although sounds proceed from the armatures of electro-magnets under the influence of undulatory currents of electricity, I have been unable to detect any audible effects due to the electro-magnets themselves. An undulatory current was passed through the coils of an electro-magnet which was held closely against the ear. No sound was perceived until a piece of iron or steel was presented to the pole of the magnet. No sounds either were observed when the undulatory current was passed through iron, steel, retort-carbon, or plumbago. In these respects an undulatory current is curiously different from an intermittent one. (See par. 2.)

16. The telephonic effects described above are produced by three distinct varieties of currents, which I term respectively intermittent, pulsatory, and undulatory. *Intermittent currents* are characterized by the alternate presence and absence of electricity upon the circuit; *pulsatory currents* result from sudden or instantaneous changes in the intensity of a continuous current; and *undulatory currents* are produced by gradual changes in the intensity of a current, analogous to the changes in the density of air occasioned by simple pendulous vibrations. The varying intensity of an undulatory current can be represented by a sinusoidal curve, or by the resultant of several sinusoidal curves.

Intermittent, pulsatory, and undulatory currents may be of two kinds, — *voltaic* or *induced;* and these varieties may be still further discriminated into *direct* and *reversed* currents; or those in which the electrical impulses are all positive or negative, and those in which they are alternately positive and negative.

* *Sullivan.* "Currents of Electricity produced by the vibration of Metals," Phil. Mag., 1845, p. 261; Arch. de l'Électr., X, p. 480.

Telephonic effects can be produced by means of currents of electricity, which are:—

- Intermittent.
  - Voltaic. — Direct (see par. 1, 2, 3, 4, 5, 6). / Reversed.
  - Induced. — Direct. / Reversed (See par. 8).
- Pulsatory.
  - Voltaic. — Direct (See par. 9). / Reserved.
  - Induced. — Direct. / Reversed.
- Undulatory.
  - Voltaic. — Direct (See par. 11, 12, 13, 15). / Reversed.
  - Induced. — Direct. / Reversed (See par. 10).

17. In conclusion, I would say that the different kinds of currents described above may be studied optically by means of König's manometric capsule.* The instrument, as I have employed it, consists simply of a gas-chamber closed by a membrane to which is attached a piece of clock-spring. When the spring is subjected to the attraction of an electro-magnet, through the coils of which a "telephonic" current of electricity is passed, the flame is thrown into vibration.

I find the instrument invaluable as a rheometer, for an ordinary galvanometer is of little or no use when "telephonic" currents are to be tested. For instance, the galvanometer needle is insensitive to the most powerful undulatory current when the impulses are reversed, and is only slightly deflected when they are direct. The manometric capsule, on the other hand, affords a means of testing the amplitude of the electrical undulations; that is, of deciding the difference between the maximum and minimum intensity of the current.

COMPLAINANTS' EXHIBIT 10.

[See Page 145.]

General Report of Judges of Centennial Exhibition, Group XXV., pages 20 and 21.

THE ELECTRIC TELEPHONE AND MULTIPLE TELEGRAPH.

The idea of transmitting sounds to a distance by means of electrical currents has been for several years before the world, and the idea of extension of this to telegraphy was evident, though no one

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* *König.* "Upon Manometric Flames," Phil. Mag., 1873, XLV., No. 297, 298.

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had thought it could lead to practical results. But the idea of a multiple electrophonic telegraph transmitting simultaneously several different musical notes for the simultaneous transmission of different messages by one wire, is an invention of high scientific character promising admirable practical results. For the honor of this invention there are two claimants, Mr. Elisha Gray, of Chicago, Illinois, and Mr. Alexander G. Bell, of Salem, Massachusetts. These inventions are independent of one another and different in the method of producing the result. In the telegraph of Mr. Gray several series of waves or impulses are simultaneously transmitted through a single wire. These impulses are excited by interruptions in the current produced by tuning-forks of different pitches, and excite, at the farther extremity of the line, corresponding variations in tuning-forks of the same pitch. Thus, if four or five tuning-forks are vibrated at the same time at one end of a line, each will excite vibrations in its corresponding fork at the other end without affecting the other forks. The exhibitors of this telegraph inform the judges that they are now able to equip lines for actual business with a capacity for carrying, through one wire, eight messages simultaneously, and there is no reason why the number may not be increased to sixteen. This telegraph may be made self-recording, or may be worked forward by relays through greater lengths of line than the insulation allows in one circuit.

The telephone of Mr. Bell aims at a still more remarkable result, — that of transmitting audible speech through long telegraphic lines. In the improved instrument the result is produced with striking effect, without the employment of an electrical current other than that produced by the mechanical action of the impulse of the breath as it issues from the lungs in producing articulate sounds. To understand this wonderful result, suppose a plate of sheet iron, about five inches square, suspended vertically before the mouth of the speaker so as to vibrate freely by the motion of the air due to the speech, and suppose also another iron plate, of the like dimensions, similarly suspended before the ear of the hearer of the sound, and between these, but not in contact with them, is stretched the long telegraphic wire. Each end of this wire is attached to two coils of insulated wire surrounding a core of soft iron, the ends of which are

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placed near the middle of the plate, but not in contact with it. These four cores are kept in a magnetic condition by being attached at each end of the line to the two poles of a permanent magnet. Now it is evident that in this arrangement any disturbance of the magnetism of one of the permanent magnets, increasing or diminishing it, will induce electrical currents, which, traversing the long wire, will produce a similar disturbance of the magnetism of the arrangement at the other end of the wire. Such a disturbance will be produced by the vibration of the plate of soft iron due to the words of the speaker, and the current thus produced, changing the magnetism of the soft iron cores, will by reaction produce corresponding vibrations in the iron plate suspended before the ear of the hearer. The vibrations of the second plate being similar to those of the first will reproduce the same sounds. Audible speech has, in this way, been transmitted to a distance of three hundred miles, perfectly intelligible to those who have become accustomed to the peculiarities of certain of the sounds. All parts of a tune are transmitted with great distinctness and with magical effect.

This telephone was exhibited in operation at the Centennial Exhibition, and was considered by the judges the greatest marvel hitherto achieved by the telegraph. The invention is yet in its infancy, and is susceptible of great improvements.

COMPLAINANTS' EXHIBIT 11.

[See Page 145.]

Reports on Awards, Group XXV., Centennial Exhibition, pages 130, 131.

3. ALEXANDER GRAHAM BELL, SALEM, MASS., U. S.

GRAHAM BELL'S ELECTRIC TELEPHONE AND MULTIPLE TELEGRAPH.

Report. — The idea of an electric telephone, or apparatus for transmitting sounds to a distance by variations of electric current through a wire, has been for many years before the world, and has been realized in several ways, differing considerably in details as to the appliances at two points of the circuit for producing the variations of electric current and for deriving perceptible effects from them. An extension of this idea to some kind of electro-phonetic telegraphy was inevitable, even though no one had thought it might

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or could lead to practically useful results. But the idea of a multiple electro-phonetic telegraph transmitting simultaneously several different musical notes, and using intermissions of these (like intermissions of currents in so many separate wires) for the simultaneous and independent transmission of different messages by one wire, is a very fine invention, of high scientific character, promising splendidly useful practical results.

This invention is claimed by Mr. Graham Bell, and he is entitled to full credit for it, even though, as I believe is the case, it has been also independently invented by others, both in England and America.

A very well worked-out realization of it is given in Mr. Bell's apparatus now exhibited. A great practical advantage of the electro-phonetic multiple telegraph over other methods of multiple telegraphy through one wire, is that no adjustment is required for varying conditions of the line to render the non-interference among the different messages perfect. Another even more important practical advantage is that it is indifferent between what points of the line and in which directions the different messages are being sent. The different messages can, in fact, be transmitted from any different points of the line, and each may be read at all other stations (whether stations from which others of the messages are being sent or not) with practically perfect non-interference. Another important advantage is that earth currents and lightning discharges will never disturb the signalling.

Mr. Graham Bell's apparatus includes an ingenious and effective instrument for automatically making and breaking an electric contact every time one of his telegraphic musical notes commences and ceases to sound. Thus his multiple telegraph may be made self-recording (after the Morse or Bain method), or may be worked forward by relay through greater lengths of line than imperfectness of the insulation allows to be worked in one circuit. Mr. Bell showed me in action two of these electro-phonetic relays, recording quite independently the transmission of independent messages by two musical notes in one wire. In addition to his electro-phonetic multiple telegraph, Mr. Graham Bell exhibits apparatus by which he has achieved a result of transcendent scientific interest, — the

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transmission of spoken words by electric currents through a telegraph wire. To obtain this result, or even to make a first step toward it, — the transmission of different qualities of sounds, such as the vowel sounds, — Mr. Bell perceived that he must produce a variation of strength of current in the telegraph wire as nearly as may be in exact proportion to the velocity of a particle of air moved by the sound; and he invented a method of doing so, a piece of iron attached to a membrane, and thus moved to and fro in the neighborhood of an electro-magnet, which has proved perfectly successful. The battery and wire of this electro-magnet are in circuit with the telegraph wire and the wire of another electro-magnet at the receiving station. This second electro-magnet has a solid bar of iron for core, which is connected at one end, by a thick disc of iron, to an iron tube surrounding the coil and bar. The free circular end of the tube constitutes one pole of the electro-magnet, and the adjacent free end of the bar-core, the other. A thin circular iron disc, held pressed against the end of the tube by the electro-magnetic attraction, and free to vibrate through a very small space without touching the central pole, constitutes the sounder by which the electric effect is reconverted into sound. With my ear pressed against this disc, I heard it speak distinctly several sentences, first of simple monosyllables, "To be or not to be" (marvellously distinct); afterwards sentences from a newspaper, "S. S. Cox has arrived" (I failed to hear the "S. S. Cox," but the "has arrived" I heard with perfect distinctness); then "City of New York," "Senator Morton," "The Senate has passed a resolution to print one thousand extra copies," "The Americans of London have made arrangements to celebrate the Fourth of July." I need scarcely say I was astonished and delighted; so were others, including some other judges of our Group, who witnessed the experiments and verified with their own ears the electric transmission of speech. This, perhaps the greatest marvel hitherto achieved by the electric telegraph, has been obtained by appliances of quite a homespun and rudimentary character. With somewhat more advanced plans, and more powerful apparatus, we may confidently expect that Mr. Bell will give us the means of making voice and spoken words audible through the electric wire to an ear hundreds of miles distant.

COMPLAINANTS' EXHIBIT 12.

[SEE PAGE 145.]

Reports on Awards, Centennial Exhibition, Group XXV., Pages 131, 132.

4. ELISHA GRAY AND SAMUEL STOCKTON WHITE, CHICAGO, ILL., U. S.

GRAY'S ELECTRIC TELEPHONE AND MULTIPLE TELEGRAPH.

Report.—The idea of an electric telephone, or apparatus for transmitting sound to a distance by variations of electric current through a wire, has been for many years before the world, and has been realized in several ways, differing considerably in details as to the appliances at two points of the circuit, for producing the variations of electric current, and for deriving perceptible effects from them. An extension of this idea to some kind of electro-phonetic telegraphy was inevitable, even though no one had thought it might or could lead to practically useful results. But the idea of a multiple electro-phonetic telegraphy transmitting simultaneously several different musical notes, and using intermissions of these (like intermissions of currents in so many separate wires) for the simultaneous and independent transmission of different messages by one wire, is a very fine invention of high scientific character, promising important useful practical results. This invention is claimed by Mr. Gray, and he is entitled to full credit for it, even though, as I believe is the case, it has been also independently invented by others, both in England and America. A very well worked-out realization of it is given in Mr. Gray's apparatus now exhibited. A great practical advantage of the electro-phonetic multiple telegraph over other methods of multiple telegraphy through one wire, is that no adjustment is required for varying conditions of the line to render the non-interference among the different messages perfect. Another even more important practical advantage is that it is indifferent between what points of the line and in which directions the different messages are being sent. The different messages can, in fact, be transmitted from any different points of the line, and each may be read at all other stations (whether stations from which others of the messages are being sent or not) with practically perfect non-interference. Another important advantage is that earth currents and light-

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ning discharges will never disturb the signalling. The exhibitors, in their "Information for the Judges," say, "We are now able to equip a line for actual business, with a capacity for carrying through each wire eight messages simultaneously, and we see no reason why the number may not be increased to sixteen without difficulty." I quite concur in the latter part of this statement, and believe that sixteen or more messages could be usefully transmitted at the same time through one land telegraph wire of many hundred miles' length, by the apparatus actually exhibited by Mr. Gray. Mr. Gray's apparatus includes an ingenious and effective instrument for automatically making and breaking an electric contact every time one of his telegraphic musical notes commences and ceases to sound. Thus his multiple telegraph may be made self-recording (after the Morse or Bain method), or may be worked forward by relay through greater lengths of line than imperfectness of the insulation allows to be worked in one circuit. Mr. Gray gave, in the Exhibition building, an exceedingly interesting and pleasing demonstration of his apparatus in action, transmitting musical performances through the wire, and letting the result be heard with marvellous brilliance at the remote end in three different ways, one of which, founded on the remarkable property of electric currents to increase or diminish friction between a moist solid and a metal in contact, discovered by Mr. Edison and used by him in his electro-motograph, is, I believe, altogether original and novel in this electro-phonetic receiving instrument of Mr. Gray's.

COMPLAINANTS' EXHIBIT 13.

[SEE PAGE 146.]

The Chicago "Tribune," Wednesday, February 28, 1877.

"THE TELEPHONE.

"LECTURE BY PROF. ELISHA GRAY AT McCORMICK HALL.

"*A large and delighted Audience — speaking by a Wire.*

"The 500 people who went to McCormick Hall last evening to "hear Elisha Gray lecture about the telephone were not only amused "but instructed, since there was almost an entire absence of techni- "cal terms in the 'Professor's' language, and everybody in the audi-

"ence could comprehend what he talked about. On the platform "was a miscellaneous assortment of telegraphic machinery, which "was used to illustrate his subject. Conspicuous in the centre was "the Telephone — sixteen large and small boxes, connected together "by wires attached to a magnet. In the center of the auditorium, "kept in position by a wire running from one gallery to the other, "was a violin, with a magnet fastened to the sounding-board.

"The lecturer was introduced by Judge Caton, and after returning "thanks for his reception, which was very cordial, said his subject "was the force called 'Electricity.' Fifty years ago it was looked "upon as something that could be used only to gratify an idle curi- "osity, such as producing convulsions in a frog's leg or twitching "the muscles of that more evolved animal, man. It was put to no "useful purpose, perhaps, except during thunder storms, to intimi- "date bad boys. But since that time it had risen until to-day it was "the peer, if not the queen, of the forces of Nature. Then it was a "terror to the sick and afflicted; now it was considered a blessing "and an important aid in the art of healing. Then it was a beggar, "knocking at the door of Congress for $20,000 to demonstrate its "usefulness to mankind. Now, $100,000,000 could not purchase "the interests that it had directly or indirectly developed. Then "the merchant did not know the price of produce outside of his town "or county. Now he had the markets of the world at his door every "half hour. It would consume too much time and tire the patience "of all to trace the progress of electrical science. Its present state "of development was not due to any one man, but to a great many "investigators, all of whom had forged a link in the chain; some of "more and others of less value. Their headaches, and heartaches, "and midnight oil, and, he might say, the use of their pocket-books, "had culminated in the grand system of iron nerves that ran over "the face of the globe, and enabled us to hourly feel the pulsations "of the great heart of the world.

"Marvelous as the triumphs of electricity had been in the past, "especially in its development of electric telegraphy, it still from "time to time brought to the surface some new wonder, so that the "constant inquiry was, what next? Lately it had shown a musical "talent and powers of ventriloquism. Much time had been required

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"to train it to sing, and a great deal of money has been paid the "teacher. Although it did not yet equal its sister, the piano, in "volume or quality of tone, it outrivaled it in the distance at which "it could be heard. The transmission of sound to a distance was "due to acoustics and electricity. It seemed to be a universal law "that everything was carried by motion. We saw motion in life, in "growth, and in death. There were various kinds of motion. One "form was sound. There was a motion we saw, but did not hear, "as the waving of a hand. If the hand could be made to vibrate "sixteen, twenty, or thirty times a second, we could hear a musical "tone. Sound was audible motion, — audible vibration. Sixteen "vibrations a second would produce a sound, and they could be in- "creased to 40,000 a second, when the sound faded out. Motion "still existed. Perhaps it became electricity. By and by it became "heat.

"He then alluded briefley to the propagation of sound waves, com- "paring them to the waves in the water when a pebble is thrown in. "They traveled ordinarily at the rate of 1,100 feet a second; some "tones went at a higher rate, and others at a lower rate. When we "came to electricity the rate could not be measured. As soon as "vibration commenced in Milwaukee or New York the sound was "heard in Chicago. The wave existed in the air or in any media as "a form — as a shape.

"There are two kinds of sound, noise and musical tone. The "former was caused by the waves striking the ear irregularly, with- "out periodicity, as that from the street. The latter was brought "about by regularity and periodicity of movement. Forty vibrations "a second was the lowest time of the piano, as commonly con- "structed. When the rate was increased the note rose in 'pitch.' "[This was illustrated by striking two tuning-forks, one representing "a high and the other a low note. One was tuned to 256 vibrations, "or 512 according to the French method, the other was its octave.]

"Passing on to electricity, he asked what it was. No one had "answered. It was a much-abused force, and had been used as a "sort of scapegoat for the explanation of everything that was mys- "terious. Everything in the heavens that could not be explained "was called electrical phenomena. He did not purpose at this late

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"day to dispel any of the prevailing ideas with reference to it by tell-
"ing what it was. Electricity was a certain condition that was called
"electrical. [Smiles.] We would know quite enough when we dis-
"covered all the facts regarding its action and its uses. One of its
"most important uses was the phenomenon demonstrated 'Electro-
"Magnetism,' upon which most of the systems of telegraphing were
"based. It was produced by passing a current of electricity spirally
"around a soft iron bar; and a singular fact was that the bar
"moved, the particles becoming polarized, and turning in their
"places, and elongating the bar itself. Professors Page and Henry
"discovered this in 1831, but stopped there. They heard a noise
"and found out the reason for it; that the bar actually lengthened,
"and in lengthening made a noise, just as any other sudden quick
"motion would. The same principle was applied in the Telephone,
"the loudness of the tone depending upon the strength of the mag-
"netic influence passed through the boxes.

"The Professor then explained the construction of the instruments
"— both the receiver and the sender — which have heretofore been
"described at length in The Tribune. An operator on the platform
"'called up' Milwaukee, where the sender was located, and a num-
"ber of simple melodies were played on the Telephone and Violin,
"much to the delight of the audience, who applauded frequently.

"Some one suggested that the manipulator be requested to play
"'Hold The Fort.' Word was sent him, but he did not respond;
"and a voice cried out, 'Perhaps they don't know the tune in Mil-
"waukee.' [Laughter.] Continuing, the lecturer said that not
"only simple but composite tones could be transmitted simulta-
"neously over the same wire. This multiplied its capacity for tele-
"graphic purposes, and was the object of the invention. Eight
"tones had thus far been transmitted, the receivers and senders cor-
"responding in tone, each pair being attuned to the same vibrations,
"and the receiver, ignoring all other tones, would pick up only that
"which came from its own sender. Everything that was capable of
"being thrown into motion, and had a rate of its own — its funda-
"mental — would cause motion in a similar instrument. [This was
"illustrated by drawing a bass-viol bow across a tuning fork and
"placing another, which gave forth the same note, in a line with it,

"the second one vibrating without being touched, on account of the "action of the air waves upon it. The operators in Milwaukee sent "four tones over the same wire, and each could be heard clearly by "those near the platform, although all were sounded at the same "time. They were also run in together, but each little receiver or "box picked up its own note and did not interfere with its neigh-"bor.]

"Another development of the Telephone was interesting in a "scientific point of view. Prof. Bell, in his investigation, had gone "a step beyond composite tones, although they were embraced in it, "and developed the transmission of vocal sounds. A spoken word "was nothing but vibrations in some of its small and complex "forms; it was almost if not quite impossible to produce a pure "tone. There were overtones, vibrating at a higher rate, connected "with every fundamental. A piece of string vibrated; so did the "two halves, the four fourths, etc., of it, the latter being the over-"tones, and giving the element which was called quality. Thus an "E could be distinguished from a U.

"The instrument for transmitting vocal sound consisted of a hol-"low tube, on one end of which was stretched a metal membrane, "with a thin iron or steel armature glued to it, the membrane swing-"ing back and forth in the air, and copying the voice in all its forms, "assuming exactly the motion of the air when a word is uttered. "The word passed through a magnet, and at the receiving end was a "similar membrane, which was thrown into vibration in the same "manner, and there was consequently audible vibration in the form "of the word. The only trouble with the instrument was, that when "set in motion, it didn't stop as suddenly as a word was ended, and "a sort of echo accompanied it, as if the operator had his head in a "barrel, as if the words were blended together. So far the words "were very low, but the voice of a friend could be easily distin-"guished, with the ear close to the receiver. Whether it would ever "be brought to a state of perfection was a great question, because "there was not the power to do it. [Applause.]"

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COMPLAINANTS' EXHIBIT 14, DOLBEAR APPLICATION, J. H. T., SPECIAL EXAMINER.

AMOS EMERSON DOLBEAR, OF SOMERVILLE, MASS., ASSIGNOR TO THE GOLD AND STOCK TELEGRAPH COMPANY OF NEW YORK CITY.

PENDING APPLICATION FILED OCT. 31, 1877.

TELEPHONIC APPARATUS.

CASE A.

To all whom it may concern:

Be it known, that I, Amos Emerson Dolbear, of Somerville, in the County of Middlesex and State of Massachusetts, have invented certain new and useful improvements in Telephonic Apparatus, which improvements are fully set forth in the following specification, reference being had to the accompanying drawings.

My invention relates to a certain class of apparatus technically known as telephones, which are especially adapted to the transmission and reproduction, at a distance, of sonorous waves or vibrations of any description, by means of electrical impulses.

My improvements consist in the employment of an elastic plate, preferably of iron or steel, which is so supported and arranged with reference to the poles of one or more magnetic cores, surrounded by coils or helices of insulated wire, that the said plate is not only capable of responding to sonorous vibrations traversing the atmosphere or other bodies, but at the same time, by its inductive action upon the magnetized core or cores, it generates a series of magneto-electric waves or pulsations in the surrounding helices, which pass through the line to the distant station. These magneto-electric waves or pulsations act in the reverse manner upon a precisely similar apparatus at the receiving station or stations; that is to say, they pass through the helices surrounding the magnetized core, generating what may for convenience be termed electro-magnetic pulsations or waves in said core, causing it to attract its corresponding elastic plate or armature with varying degrees of force, and thus throwing the latter into vibrations, which are in every essential particular the

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counterpart of the vibrations of the corresponding plate at the sending station. These vibrations being communicated through the air or otherwise to the ear, produce an effect which is substantially the same as that which would have been produced by the original sonorous vibrations which acted upon the elastic plate at the transmitting station. My invention further consists in combining with the said magnetic core, helices and inductive plates or armatures, permanent magnets for the purpose of maintaining the cores in a uniformly magnetic state, and also in giving to the poles of the magnetic cores which act upon and are acted upon by the elastic induction plate or armature, a conical or rounded form. My invention further consists in a call or signal fork of peculiar construction, which may be conveniently made use of in connection with the apparatus hereinbefore mentioned, for the purpose of attracting the attention of any person in the vicinity of the instrument at the receiving station or stations.

In the accompanying drawing, Figure 1 is a side elevation of my improved transmitting and receiving instrument.

Figure 2 is a vertical longitudinal section of a portion of the same, taken in the plane of the line A, B, in Figure 3.

Figure 3 is a top or plan view showing the manner of connecting two instruments in a metallic circuit, for correspondence.

Figure 4 is similar to Figure 3, except that the earth is employed for the return circuit instead of a conducting wire.

Figure 5 is a diagram representing a number of instruments such as represented in Figure 1, arranged in a telegraphic circuit.

Figure 6 is a similar diagram showing a modified form of the apparatus, and

Figure 7 is a longitudinal section of an instrument of the modified form, showing the construction, arrangement and mode of using the call or signalling fork.

In the drawings, *a* represents the base of the instrument; *b* is a permanent magnet of the U or horseshoe form, which I usually prefer to construct of three or more plates, 1, 2, 3, separately magnetized, and afterward combined into a single compound magnet, which may conveniently be mounted as shown upon a pedestal

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c, and secured in position by the yoke *d* and the bolt *e*, which passes through the several parts and binds them together.

The soft iron cores *i* and *i'* of the helices or coils *j* and *j'* are mounted upon the poles of the permanent magnet *b*, in such a way as to receive magnetism therefrom by induction. I have done this in the manner shown, by clamping the ends of the cores between the projecting outer plates 1 and 3, of the compound magnet *b*, by means of the bars *f*, *g*, and screw *h*; but the same result may be reached by other methods, as for instance, by tapping holes in the poles of the permanent magnet, and screwing the cores therein. The inductive plate or armature *m* consists of a sheet of iron or steel, which may be of circular, rectangular or other convenient form, and the edges of which are rigidly secured by screws or otherwise to a solid support or frame *k*, with an opening *l* in the centre, of considerable size. This inductive plate or armature is placed transversely in front of, and in close proximity to, the poles of the cores *i i'*, as best seen in Figure 2. The helices *j* and *j'* are connected by wires *n* and *o*, passing through the base with binding screws *p* and *p'*.

In Figure 3, *r* and *s* are the wires connecting the two stations and forming the principal portion of the main circuit. In Figure 4, the ends of the wire *s* are connected with the earth, which in this case completes the circuit instead of the metallic wire.

The most useful practical application of my invention, is for the purpose of transmitting oral communications, and in this case the operation of the apparatus is as follows: Two or more instruments being connected in a circuit in the manner shown in the figures, the person desiring to transmit an oral communication places his mouth at or near the aperture *l*, or in the vicinity of the inductive plate *m* (for example, at instrument *C*, Figure 5), and speaks the message to be transmitted. The voice of the person speaking produces in the air sonorous vibrations or waves, these being of varying amplitude and succeeding each other at varying intervals of time. The inductive plate *m*, being fixed at the edges, but elastic and free to vibrate in the centre, opposite the poles of the magnetic cores *j j*, is thrown into vibrations which correspond, in their amplitude and in their

A. E. Dolbear,

6 Sheets. Sheet 1.

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Telephonic Telegraphs.

Filed Oct. 15, 1877.

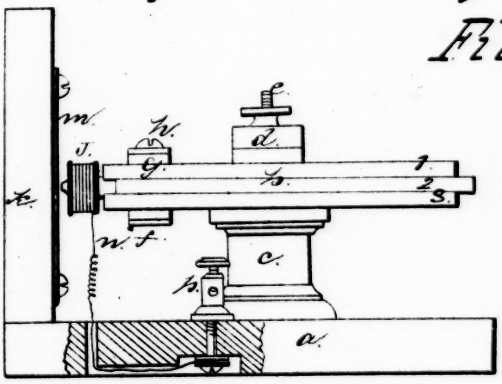


Fig: 1.

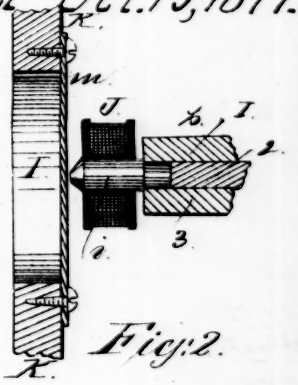


Fig: 2.

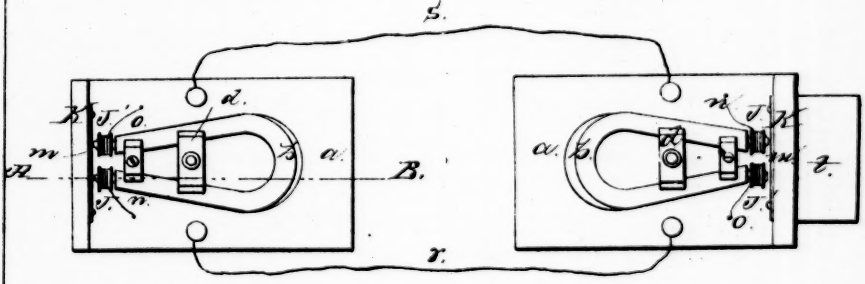


Fig: 3.

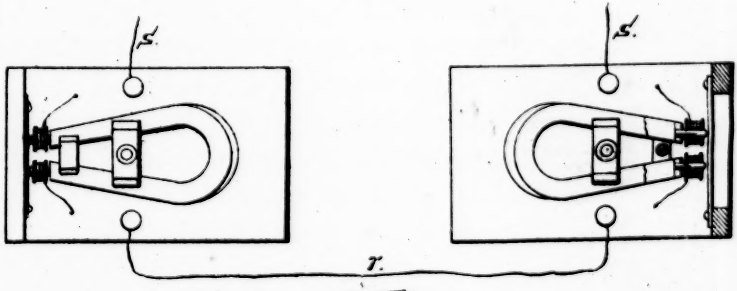


Fig: 4.

Witnesses:

James L. Norris

J. A. Rutherford

Inventor:

Amos Emerson Dolbear

by Frank L. Poe, attorney

2 Sheets. Sheet 2

A. E. Dolbear, 347

Telephonic Telegraphs.

Filed Oct. 15, 1877.

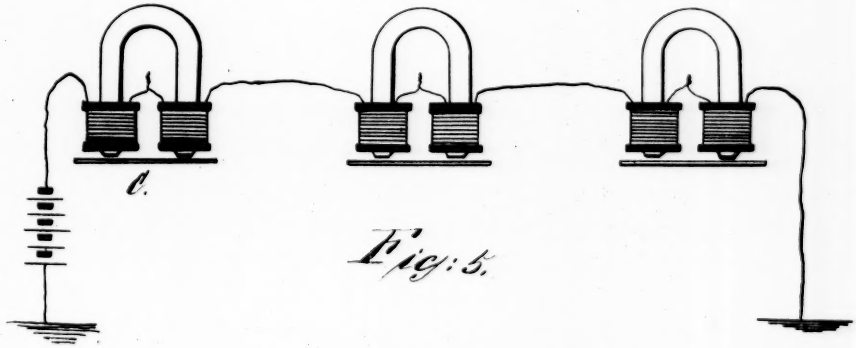


Fig: 5.

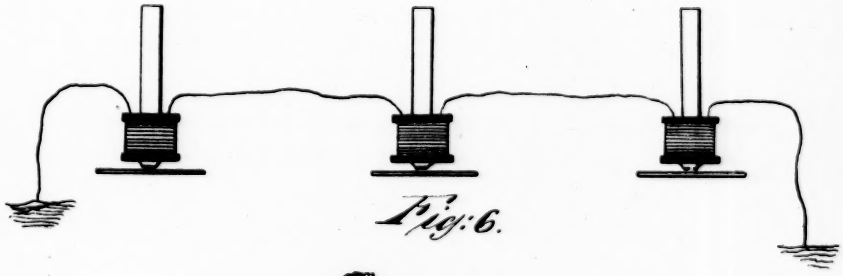
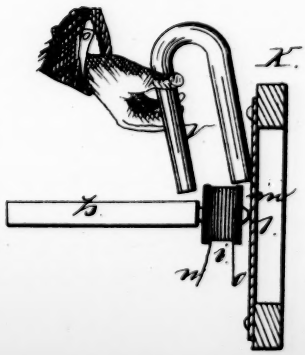


Fig: 6.



Witnesses:

James L. Norris

J. A. Rutherford.

Inventor:

Amos Emerson Dolbear

by Frank L. Pope atty.

varying intervals, with the sound vibrations of the atmosphere which impinge against it.

It has long been known that when an iron armature is caused to approach toward or withdraw from the pole of a magnetized core which is surrounded by a helix or coil of insulated wire, that a current of electricity is generated in the latter, by each movement of the armature. The polarity or direction of this current depends upon the direction in which the armature is moving, whether to or from the magnet, while its electro-motive force depends upon the ratio of the distance through which the armature moves to the time consumed in so moving. Thus it will be readily understood that the rise and fall of magnetic intensity in the cores i and i', and consequently the rise and fall of electro-motive force in the surrounding coils or helices under the influence of the vibrating inductor or armature, if graphically represented in a well-known manner, would exhibit an irregular series of sinusoidal curves, which would closely correspond with a series of curves representing the sonorous vibrations which were produced in the air by the voice of the person speaking into the instrument. Passing through the main circuit to the receiving instrument (which is precisely similar in all respects to the transmitting instrument), the electric pulsations give rise to varying magnetic intensities in the cores i, i', which in turn, by their varying attraction exerted upon the plate or armature, throw it into vibrations.

These vibrations are communicated to the air and thence to the ear of the listener, thus faithfully reproducing the original sounds uttered by the person at the sending station. It is obvious that sounds of any other character may be reproduced in precisely the same way.

If two or more persons simultaneously speak in the vicinity of the same or of different instruments, the words or other sounds uttered by them will be reproduced by all the other instruments in the same circuit.

A bonnet or tube t may be attached to the frame k, as shown, or in any other convenient manner; but although it facilitates speaking and hearing, it is not essential to the successful operation of the instrument.

The cores i, i', may be formed of soft iron, and united with the

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permanent magnet *b*, as shown, or they may be formed as a constituent part of the latter, but the former arrangement will usually be found preferable. In any case it is advantageous to give the poles which face the plate *m*, a rounded or conical form, so as to concentrate the inductive action upon as small an area as possible, as much better results are attained thereby.

The usual means of adjustment of the relative position of the cores and armature, which are made use of in ordinary telegraphic apparatus, may be applied with advantage to the instrument shown. The application of these devices is well understood, and need not be described in this place.

In Figures 6 and 7, I have shown an instrument similar to that shown in Figures 1 and 2, except that a straight or bar permanent magnet is made use of instead of a horse-shoe magnet, and a single core and helix is mounted upon a pole thereof. This modification is less powerful than that previously described, but being more portable, and of simpler construction, may in some cases be found preferable for use.

The construction and mode of operation of the call or signalling fork *v*, is shown in Figure 7. This consists of a bar, preferably of steel and U shaped, and may be employed to call the attention of any person or persons at the distant station, by striking it against some hard substance, and then placing one of its extremities or prongs lightly in contact with the inductive plate *m*, as shown in the figure, the latter is thrown into rapid vibration, which being reproduced at the receiving station in the same manner as other sounds, constitutes an efficient alarm or call.

It is not absolutely necessary that the plate *m* should be rigidly supported at more than one of its edges in order to produce the effects hereinbefore described, but I prefer to support it rigidly at all its exterior edges, as described, leaving the middle portion free to vibrate in the manner and for the purpose hereinbefore explained.

The apparatus which has been described may be placed in an ordinary telegraphic circuit traversed by a constant current from a galvanic battery or batteries, as shown in Figure 5.

The instruments should preferably be so placed that the action of

the current traversing the helices will tend to increase the magnetic effect, instead of diminishing it.

I claim as my invention: —

1. One or more helices, or coils, forming a portion of the main circuit, and surrounding a core or cores mantained in a magnetic state by the inductive influence either of an electric current or of a permanent magnet, in combination with an elastic inductive plate or armature which is rigidly supported at one or more of its edges, while the portion facing the poles of the magnetic core or cores is left free so as to be capable of responding to sonorous vibrations traversing the atmosphere or other bodies.

2. Two iron or steel cores, respectively mounted upon the opposite poles of a permanent magnet, receiving magnetism therefrom by induction, and provided with enveloping helices of insulated wire, which form a portion of the main circuit, in combination with an elastic induction plate or armature, rigidly supported at one or more of its edges, while the portion thereof facing the poles of the magnetic core or cores is left free, so as to be capable of responding either to sonorous vibrations traversing the atmosphere or other bodies, or to electro-magnetic pulsations or undulations traversing the helices surrounding the magnetic cores.

3. One or more helices or coils included in the circuit of the main line and surrounding a core or cores, in combination with an elastic inductive plate or armature facing the poles of said core or cores, and a rigid support or frame to which the opposite edges of said plate or armature are secured.

4. A magnetic core enclosed within a helix or coil of insulated wire, the pole of which is of a conical or rounded form, in combination with an elastic inductive plate or armature.

5. A call or signalling fork, constructed and operated substantially as described, in combination with the inductive plate or armature of a magneto-electric telegraphic or telephonic apparatus.

In witnesses whereof, I have hereunto set my hand, this sixth day of September, A. D. 1877.

AMOS EMERSON DOLBEAR.

Witnesses:

L. EUGENE LEFFERT.

WM. ARNOUX.

3479

1877 . . . . . Townsend . . 118

Div. 16 1

No. . . . . A.

AMOS EMERSON DOLBEAR, *Ass'or to The Gold and Stock Telegraph Company, of New York City.*
Of Somerville,
County of Middlesex,
State of Massachusetts.

TELEPHONIC APPARATUS.

Rec'd, Oct. 15, 1877.
Petition, " " "
Affidavit, " " "
Specification, " " "
Drawing, Octr. 31, "
Model, Augt. 24, "
Cert. dep.
1. Cash, $15, Oct. 15, 1877.
Add'l Fee Cert.
" " Cash.
Examined.
2. Issue.
3. Patented, 187 .
Circular.

FRANK L. POPE, *Elizabeth, N. J.*
JAMES L. NORRIS, *Asso. Present.*

1877.

CONTENTS.

APPLICATION PAPERS.

	1.	Rej.,	Nov. 3d, 1877.
	2.	Letter from Att'y,	Nov. 7, 77.
A	3.	Int'f. × $\frac{116}{73}$, $\frac{72}{64}$, $\frac{86}{12}$, $\frac{104}{58}$, $\frac{135}{90}$, $\frac{158}{58}$.	Mar. 26, 1878.
E	4.	Int'f. × $\frac{126}{48}$, $\frac{104}{58}$, $\frac{116}{71}$, $\frac{135}{90}$, $\frac{158}{58}$.	Mar. 26, 1878.
F	5.	Int'f. × $\frac{135}{90}$, $\frac{116}{73}$, $\frac{158}{58}$.	Mar. 26, 1878.
G	6.	Int'f. × $\frac{116}{71}$, $\frac{104}{58}$, $\frac{128}{85}$, $\frac{135}{90}$, $\frac{176}{32}$, $\frac{158}{58}$.	Mar. 26, 1878.

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H 7.	Int'f. × $\frac{135}{90}$, $\frac{116}{73}$, $\frac{158}{58}$.	Mar. 26, 1878.
I 8.	Int'f. × $\frac{116}{73}$, $\frac{135}{90}$, $\frac{42}{26}$.	Mar. 26, 1878.
J 9.	Int'f. × $\frac{128}{85}$, $\frac{104}{58}$, $\frac{116}{71}$, $\frac{135}{90}$, $\frac{42}{26}$.	Mar. 26, 1878.
K 10.	Int'f. × $\frac{42}{26}$.	Mar. 26, 1878.
11.	Int'f. × 4/54.	May 14, 1878.
12.	Int'f. × 4/54, Five.	June 13, 1878.
13.		
14.		
15.		
16.		
17.		
18.		

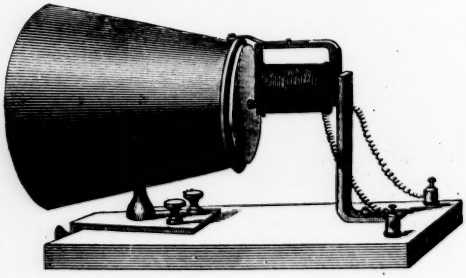
TITLE.

Ex. J. A. W. Improvement in
M. McK. 36 *Electricity*
Telephonic Telegraphs.

3479

COMPLAINANTS' EXHIBIT NO. 15, MEMBRANE TELEPHONE NO. 2, TRANSMITTER.

(Record, Page 382.)



DIMENSIONS.

Length of cone	6	inches.
Diameter of mouth of cone	6	"
Diameter of membrane	$3_{\frac{3}{8}}$	"
Length of armature	2	"
Length of spool	2	"
Diameter of spool	$1\frac{5}{8}$	"

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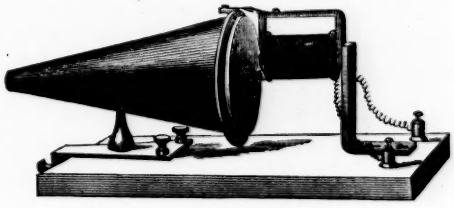
COMPLAINANTS' EXHIBIT NO. 16, MEMBRANE TELEPHONE NO. 2, RECEIVER.

(RECORD, PAGE 382.)



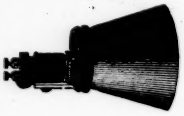
DIMENSIONS.

Length of cone	7	inches.
Diameter of membrane	$3\frac{3}{8}$	"
Diameter of end of cone	$\frac{1}{2}$	"
Length of armature	$1\frac{7}{8}$	"
Length of spool	2	"
Diameter of spool	$1\frac{3}{8}$	"

3481

COMPLAINANTS' EXHIBIT NO. 17, BABY MEMBRANE TELEPHONE TRANSMITTER.

(RECORD, PAGE 384.)



DIMENSIONS.

Length of cone	$1\frac{1}{2}$	inches.
Diameter of mouth of cone	$1\frac{3}{4}$	"
Diameter of membrane	1	"
Length of spool	$\frac{1}{2}$	"
Diameter of spool	$\frac{1}{3}$	"
Length of armature	$\frac{1}{2}$	"
Width of armature	$\frac{1}{5}$	"

COMPLAINANTS' EXHIBIT NO. 18, BABY MEMBRANE TELEPHONE, RECEIVER.

(RECORD, PAGE 384.)

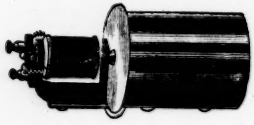
DIMENSIONS.

Length of cone	$1\frac{1}{2}$ inches.
Diameter of small end of cone	$\frac{1}{4}$ "
Diameter of membrane	1 "
Length of spool	$\frac{1}{2}$ "
Diameter of spool	$\frac{1}{3}$ "
Length of armature	$\frac{1}{2}$ "
Width of armature	$\frac{1}{5}$ "

3483

COMPLAINANTS' EXHIBIT NO. 19, LOVER'S ELECTRIC TELEPHONE.

(RECORD, PAGE 385.)

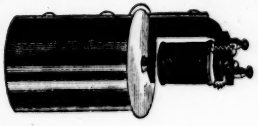


DIMENSIONS.

Length of cylinder	2	inches.
Diameter of cylinder	$1\frac{1}{2}$	"
Length of spool	$\frac{5}{6}$	"
Diameter of spool	$\frac{3}{4}$	"
Length of armature	1	"
Width of armature	$\frac{1}{2}$	"

COMPLAINANTS' EXHIBIT NO. 20, LOVER'S ELECTRIC TELEPHONE.

(RECORD, PAGE 385.)

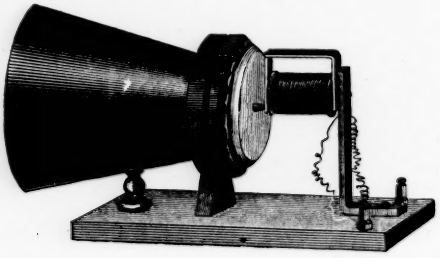


This is a duplicate of complainants' Exhibit No. 19.

3485

COMPLAINANTS' EXHIBIT NO. 21, ADJUSTABLE MEMBRANE TELEPHONE, TRANSMITTER.

(RECORD, PAGE 385.)



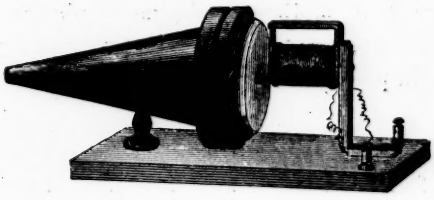
DIMENSIONS.

Length of cone	$5\frac{3}{4}$	inches.
Diameter of large end of cone	6	"
Diameter of membrane	$3\frac{1}{4}$	"
Length of spool	2	"
Diameter of spool	$1\frac{3}{8}$	"
Length of armature	$1\frac{7}{8}$	"
Width of armature	$\frac{2}{5}$	"

3486

COMPLAINANTS' EXHIBIT NO 22, ADJUSTABLE MEMBRANE TELEPHONE, RECEIVER.

(RECORD, PAGE 385.)



DIMENSIONS.

Length of cone	$6\frac{3}{4}$	inches.
Diameter of membrane	$3\frac{1}{4}$	"
Diameter of spool	$1\frac{3}{8}$	"
Length of spool	2	"
Length of armature	$1\frac{3}{4}$	"
Width of armature	$\frac{3}{8}$	"

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COMPLAINANTS' EXHIBITS NOS. 23 AND 24, HAND TELEPHONE MEMBRANES.

(RECORD, PAGE 387.)

These are two similar membrane diaphragms, carrying hinged armatures, adapted for use on two ordinary Bell hand telephones, in place of the usual metal diaphragms.

DIMENSIONS.

Diameter of membrane	$2\frac{1}{4}$ inches.
Length of armature	$1\frac{1}{12}$ "
Width of armature	$\frac{7}{16}$ "
Thickness of armature	$\frac{1}{16}$ "

3488

COMPLAINANTS' EXHIBIT NO. 25, BELL HAND TELEPHONE. (Sectional View.)

(RECORD, PAGE 388.)

DIMENSIONS.

Length of permanent magnet . . .	$4\frac{3}{4}$	inches.
Length of soft iron core	$\frac{5}{8}$	"
Length of spool	$\frac{1}{2}$	"
Diameter of spool	1	"
Diameter of core	$\frac{1}{4}$	"
Diameter of diaphragm	$1\frac{3}{4}$	"

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COMPLAINANTS' EXHIBIT NO. 26, BELL HAND TELEPHONE WITH LENGTHENED CAP PIECE.

(RECORD, PAGE 388.)

COMPLAINANTS' EXHIBIT NO. 27, HELIOTYPE I.

(RECORD, PAGE 396.)

3490

Complainants' Exhibit 27.

Plate I.

W. P. Preble Jr Examiner

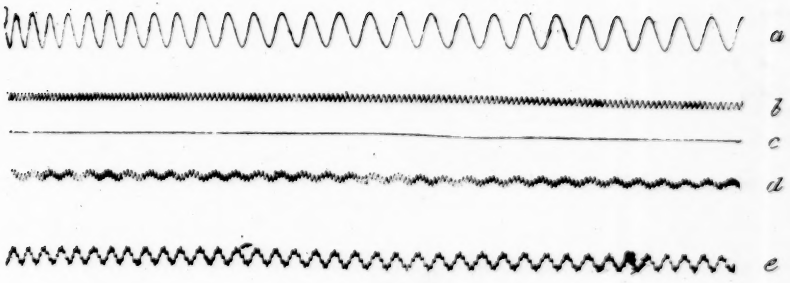


FIG. I.

TUNING FORK.

3491

Complainants' Exhibit 27.
Plate II.
H. P. Preble Jr Examiner

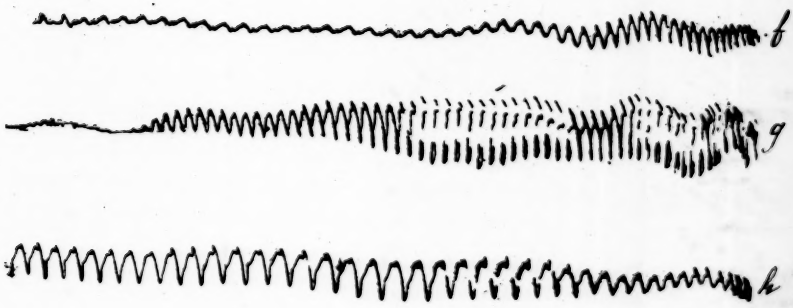


FIG. 2.
TROMBONE.

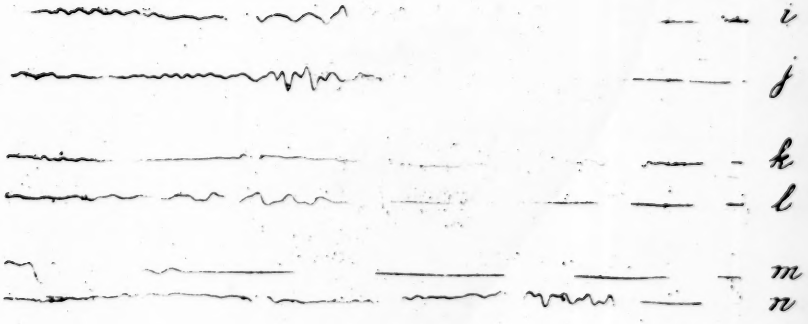


FIG. 3.
A BLOW.

COMPLAINANTS' EXHIBIT NO. 27, HELIOTYPE III.

(RECORD, PAGE 396)

3492

Complainants' Exhibit 27.
Plate III.
W. P. Preble Jr Examiner

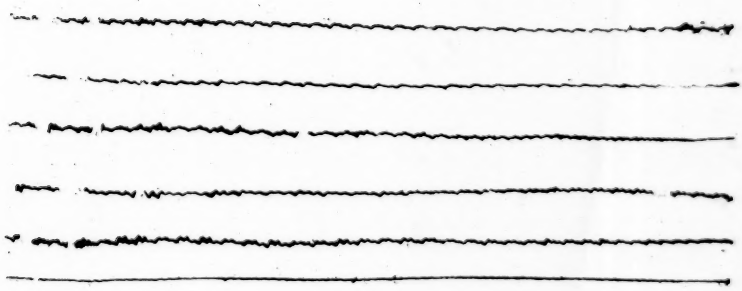


FIG. 4.
long a.(ā)

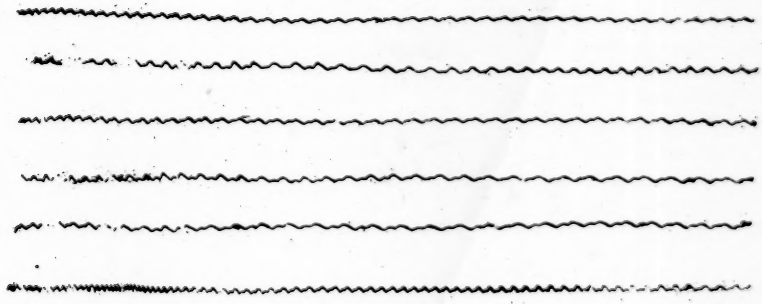


FIG 5.
long e.(ē)

COMPLAINANTS' EXHIBIT NO. 27, HELIOTYPE III.

(RECORD, PAGE 396)

3492

Complainants' Exhibit 27.
Plate III.
W. P. Preble Jr Examiner

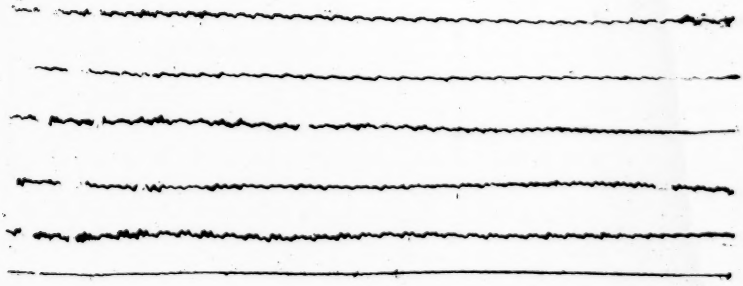


FIG. 4.
long a.(ā)

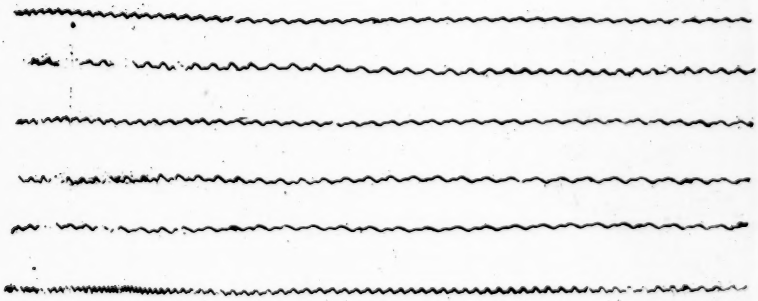


FIG 5.
long e.(ē)

3493

Complainants' Exhibit 27.
Plate IV.
H. P. Preble Jr Examiner.

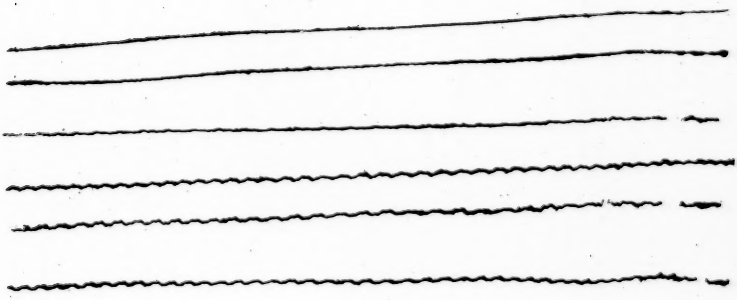


FIG. 6.
long i (ī)

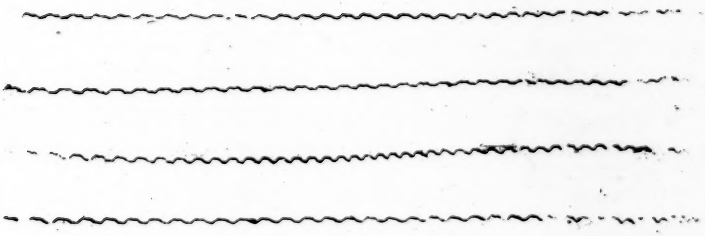
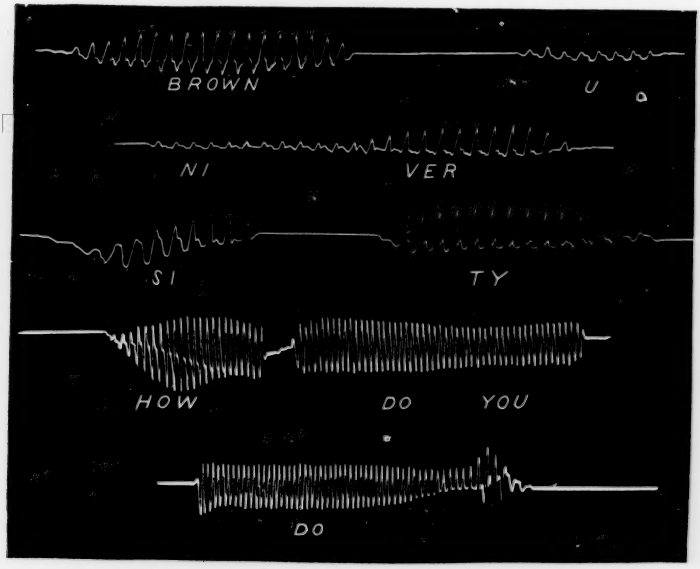
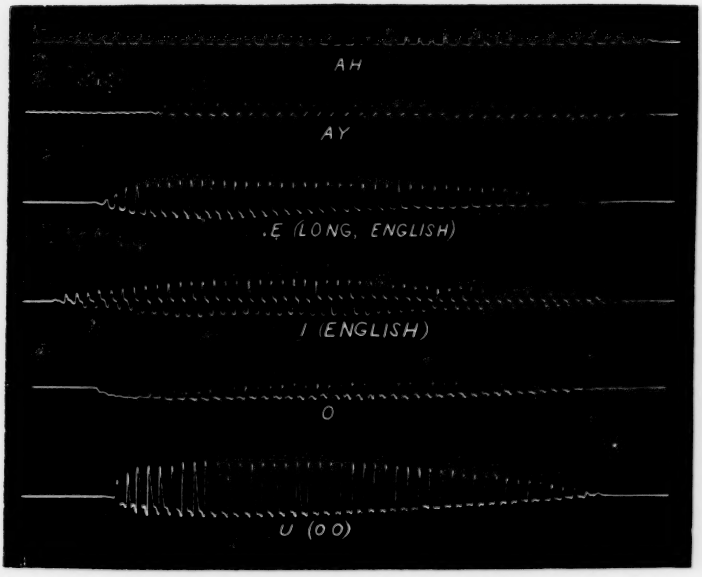


FIG. 7.
long o. (ō)

COMPLAINANTS' EXHIBIT NO. 28, ARTICULATE CURVES.

(Record, Page 338.)





COMPLAINANTS' EXHIBIT NO. 29, COMPOUND CURVE.

(RECORD, PAGE 398.)

COMPLAINANTS' EXHIBIT No. 30, DR. C. J. BLAKE'S DRAWINGS.

(RECORD, PAGE 457.)

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No VII

Complainant's Exhibit 30
Dr. C. J. Blake. Drawings
W. P. Blake & Son

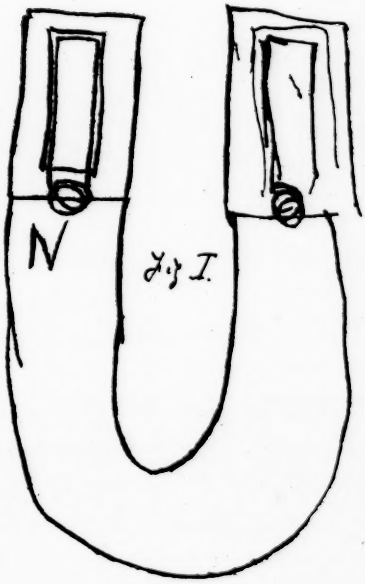


Fig I.

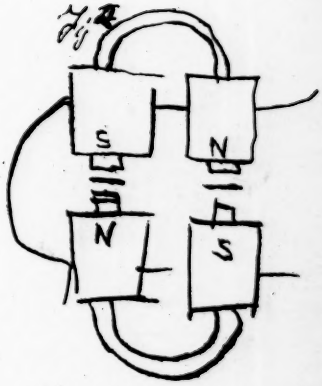


Fig 2

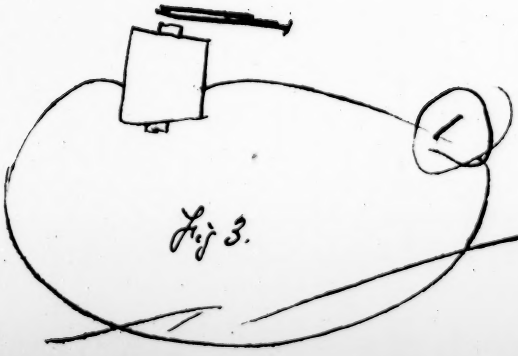


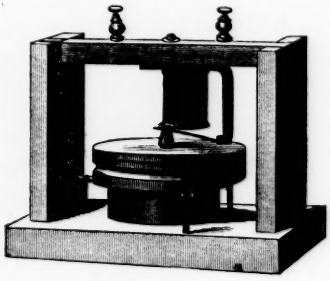
Fig 3.

Fig. 4.

3497

COMPLAINANTS' EXHIBIT NO. 31, BELL TELEPHONE OF 1875 (Duplicate).

(RECORD, PAGE 474.)



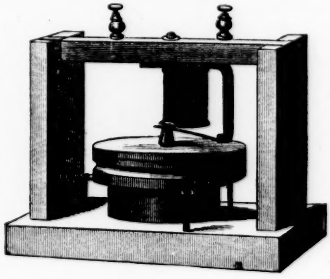
DIMENSIONS.

Diameter of membrane	4	inches.
Diameter of spool	$1\frac{1}{4}$	"
Length of spool	$1\frac{1}{2}$	"
Length of armature	2	"
Width of armature	$\frac{1}{2}$	"
Depth of tube from mouth to membrane	3	"

3497

COMPLAINANTS' EXHIBIT NO. 31, BELL TELEPHONE OF 1875 (Duplicate).

(RECORD, PAGE 474.)



DIMENSIONS.

Diameter of membrane	4	inches.
Diameter of spool	$1\frac{1}{4}$	"
Length of spool	$1\frac{1}{2}$	"
Length of armature	2	"
Width of armature	$\frac{1}{2}$	"
Depth of tube from mouth to membrane	3	"

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COMPLAINANTS' EXHIBIT NO. 32, BELL TELEPHONE OF 1875, SHEEPSKIN DIAPHRAGM.

(RECORD, PAGE 474.)

This is a membrane of sheep-skin stretched on a wooden ring of the same dimensions as the ring in Complainants' Exhibit No. 31, and adapted to be substituted for the ring and membrane of gold-beater's skin, in Exhibit 31.

Diameter of membrane . . . . . 4 inches.

COMPLAINANTS' EXHIBIT NO. 33, BELL TELEPHONE OF 1875, HEAVY ARMATURE.

(RECORD, PAGE 474.)

This is a heavy armature, used as a substitute for the armature in Exhibit No. 31.

DIMENSIONS.

Length of armature	$1\frac{7}{8}$ inches.
Width of armature	$\frac{1}{2}$ "
Thickness of armature	$\frac{1}{8}$ "

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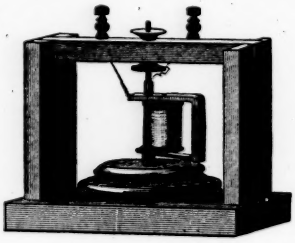
COMPLAINANTS' EXHIBIT NO. 34, SECOND BELL TELEPHONE OF 1875, DUPLICATE.

(Record, Page 479.)



DIMENSIONS.

Diameter of membrane	$2\frac{3}{4}$	inches.
Diameter of spool	$1\frac{1}{4}$	"
Length of spool	$1\frac{1}{2}$	"
Length of armature	2	"
Width of armature	$\frac{1}{2}$	"

COMPLAINANTS' EXHIBIT NO. 35, SECOND BELL TELEPHONE OF 1875, SHEEPSKIN MEMBRANE.

[RECORD, PAGE 479.]

This is a membrane of sheepskin, stretched on a wooden ring of the same dimensions as the ring in complainants' Exhibit No. 34, and adapted to be substituted for the ring and membrane of gold-beater's skin in said Exhibit 34.

Diameter of membrane 2¾ inches.

COMPLAINANTS' EXHIBIT 36, BELL'S APPLICATION OF 1876, W. P. PREBLE, JR., EXAMINER.

[RECORD, PAGE 492.]

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, greeting:

This is to certify that the annexed is a true copy from the files of this office of the file-wrapper and contents, in the matter of the Letters Patent granted Alexander Graham Bell, March 7, 1876, No. 174,465, for improvement in telegraphy.

In testimony whereof, I, W. H. Doolittle, Acting Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed, this tenth day of April, in [SEAL] the year of our Lord one thousand eight hundred and seventy-nine, and of the Independence of the United States the one hundred and third.

W. H. DOOLITTLE,

Acting Commissioner.

To the Commissioner of Patents:

Your petitioner, Alexander Graham Bell, of Salem, Mass., prays that Letters Patent may be granted to him for the invention set forth in the annexed specification.

And he hereby appoints Pollok and Bailey of Washington, D. C., his attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.

ALEX. GRAHAM BELL.

Witnesses to signature:
THOMAS E. BARRY,
P. D. RICHARDS.

To whom it may concern:

Be it known that I, Alexander Graham Bell, of Salem, Massachusetts, have invented certain new and useful improvements in telegraphy, of which the following is a specification:

In Letters Patent granted to me, April 6, 1875, No. 161,739, I have described a method of, and apparatus for transmitting two or more telegraphic signals simultaneously along a single wire by the employment of transmitting instruments, each of which occasions a succession of electrical impulses differing in rate from the others; and of receiving instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note (tone) by one only of the transmitting instruments; and of vibratory circuit breakers, operating to convert the vibratory movement of the receiving instrument into a permanent make or break (as the case may be) of a local circuit, in which is placed a Morse sounder, register or other telegraphic apparatus. I have also therein described a form of autograph telegraph based upon the action of the above mentioned instruments.

In illustration of my method of multiple telegraphy, I have shown in the patent aforesaid, as one form of transmitting instrument, an electro-magnet having a steel spring armature which is kept in vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent

current upon the line wire. I have found, however, that upon this plan the limit to the number of signals that can be sent simultaneously over the same circuit (wire) is very speedily reached; for when a number of transmitting instruments having different rates of vibration are simultaneously making and breaking the same circuit, the effect upon the main line is practically equivalent to one continuous current.

[* My present invention consists in the employment of a vibratory (or undulatory) current of electricity in place of a merely intermittent one, and of a method of, and apparatus for, producing electrical undulations upon the line wire.]

The advantages I claim to derive from the use of an undulatory current, in place of a merely intermittent one, are: —

1. That a very much larger number of signals can be transmitted simultaneously over (on) the same circuit.

2. That a closed circuit and single main battery may be used (employed).

3. That communication in both directions is established without the necessity of using special induction coils.

4. And that cable despatches may be transmitted more rapidly than by means of an intermittent current, or by the methods at present in use; for, as it is unnecessary to discharge the cable before a new signal can be made, the lagging of cable signals is prevented.

5. And that as the circuit is never broken, a spark arrester becomes unnecessary.

It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet, a current of electricity is induced in the coils of the latter, and that when it is made to recede, a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond in rapidity of succession to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration.

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* Erase and insert per Amdt. A, Feb. 29, '76.

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That the difference between an undulatory and an intermittent current may be more clearly understood, I shall describe the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously, first upon the one plan, and then upon the other.

Let the interval between the two sounds be a major third; then their rates of vibration are in the ratio of 4 : 5. Now when the intermittent current is used, the circuit is made and broken four times by one transmitting instrument in the same time that five makes and breaks are caused by the other. A and B, Figures 1, 2 and 3, represent the intermittent currents produced, four impulses of B (A) being made in the same time as five impulses of A (B); *c c c*, etc., show where and for how long time the circuit is made, and *d d d*, etc., indicate the duration of the breaks of the circuit. The line A and B shows the total effect upon the current when the transmitting instruments for A and B are caused simultaneously to make and break the same circuit. The resultant effect depends very much upon the duration of the make relatively to the break. In Figure 1, the ratio is as 1 : 4; in Figure 2, as 1 : 2; and in Figure 3, the makes and breaks are of equal duration.

The combined effect of A and B, Figure3, is very nearly equivalent to a continuous current.

When many transmitting instruments of different rates of vibration are simultaneously making and breaking the same circuit, the current upon the main line becomes for all practical purposes continuous.

Next consider the effect when an undulatory current is employed. Electrical undulations induced by the vibration of a body capable of inductive action can be represented graphically without error by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air: for, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body, that is, to the pitch of the sound produced; the intensity of the current varies with the amplitude of the vibration, that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body, that is, to the condensations and rarefactions

of air produced by the vibration. Hence the sinusoidal curve A or B, Figure 4, represents graphically the electrical undulations induced in a circuit by the vibration of a body capable of inductive action.

The horizontal line, *a d e f*, etc., represents the zero of current; the elevations, *b b b* (*c c c*), etc., indicate impulses of positive electricity; the depressions, *c c c* (*e e e*), etc., show impulses of negative electricity; the vertical distance, *b d* (*e d*) *or c f* (*e f*), of any portion of the curve from the zero line expresses the intensity of the positive or negative impulse at the part observed, and the horizontal distance *a a* indicates the duration of the electrical oscillation. The vibrations represented by the sinusoidal curves B (A) and A (B), Figure 4, are in the ratio aforesaid of 4 : 5, that is, four oscillations of B (A) are made in the same time as five oscillations of A (B).

The combined effect of A and B, when induced simultaneously on the same circuit, is expressed by the curve A + B, Figure 4, which is the algebraical sum of the sinusoidal curves A and B.

This curve, A + B, also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously. Thus when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing bodies. Hence the coexistence upon a telegraphic circuit of electrical vibrations of different pitch is manifested, not by the obliteration of the vibratory character of the current, but by peculiarities in the shapes of the electrical undulations, or in other words, by peculiarities in the shapes of the curves which represent those undulations.

There are many ways of producing undulatory currents of electricity, but all of them depend for effect upon the vibrations or motion of bodies capable of inductive action. A few of the methods that may be employed I shall here specify. When a wire through which a continuous current of electricity is passing is caused to vibrate in the neighborhood of another wire, an undulatory current of electricity is induced in the latter. When a cylinder upon which are arranged bar magnets is made to rotate in front of the pole of an electro-magnet, an undulatory current (of electricity) is induced in the coils of the electro-magnet.

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Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action; or by the vibration of the conducting wire itself in the neighborhood of such bodies. (Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery.) The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them farther apart. The reciprocal vibration of the elements of a battery therefore occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance, let mercury or some other liquid form part of a voltaic circuit, then the more deeply the conducting wire is immersed in the mercury or other liquid, the less resistance does the liquid offer to the passage of the current. Hence the vibration of the conducting wire in mercury or other liquid included in the circuit occasions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which they are immersed produce an undulatory action in the current by alternately increasing and diminishing the power of the battery.

In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose an electro-magnet A, Figure 5, having a coil upon only one of its legs *b*. A steel spring armature *c* is firmly clamped by one extremity to the uncovered leg *d* of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature *c* can be set in vibration in a variety of ways, one of which is by wind, and in vibrating it produces (yields) a musical note of a certain definite pitch.

When the instrument A is placed in a voltaic circuit, *g b e f g*, the armature *c* becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature *c* remains at rest, no effect is produced upon the voltaic current, but the moment it is set in vibration to produce its musical note a powerful inductive action takes place, and electrical undulations traverse the circuit *g b e f g*. The vibratory current, passing through the coil of the distant electro-magnet *f*, causes vibration in its armature *h*, when the armatures *c h* of the two instruments A I

are nominally in unison with one another, but the armature *h* is unaffected by the passage of the undulatory current, when the pitches of the two instruments, A I, are different.

A number of instruments may be placed upon a telegraphic circuit as in Figure 6. When the armature of any one of the instruments is set in vibration, all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration remain silent. Thus if A, Figure 6, is set in vibration, the armatures of A^1 and A^2 will vibrate also, but all the others on the circuit will remain still. So if B^1 is caused to emit its musical note, the instruments B B^2 respond. They continue sounding so long as the mechanical vibration of B^1 is continued, but become silent the moment its motion stops.

The duration of the sound may be used (made) to indicate (signify) the dot or dash of the Morse alphabet, and thus a telegraphic despatch may be indicated (can be transmitted) by alternately interrupting and renewing the sound.

When two or more instruments of different pitch are simultaneously caused to vibrate, all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to that one only of the transmitting instruments with which it is in unison. Thus the signals of A, Figure 6, are repeated by A^1 and A^2 but by no other instrument upon the circuit, the signals of B^2, by B and B^1, and the signals of C^1, by C and C^2, whether A, B^2 and C^1 are successively or simultaneously caused to vibrate (set in vibration). Hence by these instruments two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

When the armature *c*, Figure 5, is mechanically set in vibration, the armature *h* responds not only in pitch, but in loudness. Thus when *c* vibrates with little amplitude, a very soft musical note proceeds from *h*; and when *c* vibrates forcibly, the amplitude of vibration of *h* is considerably increased, and the (resulting) sound becomes

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louder. So if A and B, Figure 6, are sounded simultaneously (A loudly and B softly) the instruments A^1 and A^2 repeat loudly the signals of A, and instruments B^1 B^2 repeat gently (softly) those of B.

One of the ways in which the armature *c*, Figure 5, may be set in vibration has been stated above to be by wind. Another mode is shown in Figure 7, whereby motion can be imparted to the armature by means of the human voice or by (the tones) means of a musical instrument.

The armature *c*, Figure 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane *a*. A cone A is used to converge sound vibrations upon the membrane. When a sound is uttered in the cone, the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion and thus electrical undulations are created (caused) upon the circuit E *b e f g*. These undulations are similar in form to the air vibrations caused by the sound, that is, they are (can be) represented graphically by similar curves.

The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L.

In this specification the three words "oscillation," "vibration" and "undulation" are used synonymously.* By the term "body capable of inductive action," I mean a body which when in motion produces dynamical electricity. I include in the category of bodies capable of inductive action brass, copper and other metals, as well as iron and steel.

Having described my invention, what I claim and desire to secure by Letters Patent is as follows: —

1. A system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity (substantially as set forth).

2. The combination (substantially as set forth) of a permanent

* Insert per Amdt. B, Feb. 29, '76.

magnet or other body capable of inductive action with a closed circuit, so that the vibration of the one shall occasion (produce) electrical undulations in the other or in itself, and this I claim, whether the permanent magnet be set in vibration in the neighborhood of the conducting wire, forming the circuit; or whether the conducting wire be set in vibration in the neighborhood of the permanent magnet; or whether the conducting wire and the permanent magnet both simultaneously be set in vibration in each other's neighborhood.

3. The method of producing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action; or by the vibration or motion of the conducting wire itself in the neighborhood of such bodies (as set forth).

4. The method of producing undulations in a continuous voltaic circuit by [gradually increasing and diminishing the resistance of the circuit or by] *gradually increasing and diminishing the power (of the battery as set forth).

5. The method of and apparatus for transmitting vocal or other sounds telegraphically as herein described by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds (substantially as set forth).

In testimony whereof I have hereunto signed my name this twentieth day of January, A. D. 1876.

ALEX. GRAHAM BELL.

Witnesses:

THOMAS E. BARRY,

P. D. RICHARDS.

STATE OF MASSACHUSETTS,

SUFFOLK COUNTY, ss.

Alexander Graham Bell, the above named petitioner, being duly sworn, deposes and says that he verily believes himself to be the original and first inventor of the Improvements in Telegraphy described and claimed in the foregoing specification; that he does not know and does not believe that the same was ever before known or

* Erase and insert per Amdt. C, Feb. 29, '76.

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used; and that he is a native of Great Britain, and has declared his intention of becoming a citizen of the United States.

ALEX. GRAHAM BELL.

Witnesses:

THOMAS E. BARRY,
P. D. RICHARDS.

Sworn to and subscribed before me, this 20th day of January, A. D. 1876.

THOMAS E. BARRY,
Notary Public.

[SEAL]

Copy sent
Feb. 19
S. R. A.

EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb'y 19, 1876.

A. G. BELL,
Care POLLOK & BAILEY, *Present.*

Telegraphy, FEB'Y 14, 1876.

In this case it is found that the 1st, 4th and 5th clauses of claim relate to matters described in a pending caveat.

The caveator has been notified to complete and this app'n is suspended for ninety days, as required by law.

Z. F. WILBER, *Ex'r.*

IN THE MATTER OF THE APPLICATION OF A. GRAHAM BELL FOR IMPTS. IN TELEGRAPHY, FILED FEBY 14, '76.

HON. COMM'R OF PATENTS:

Sir, — In this matter we beg to acknowledge receipt of official letter, notifying us of the suspension of our application for completion of an interfering caveat.

We respectfully request, before it is concluded to suspend our application for three months, that you determine whether or not our application was not filed prior to the caveat in question.

We have inquired the date of filing of the caveat (inasmuch as we are entitled to the knowledge) and find it to be February 14, 1876, the same day on which our application was filed. If our applica-

tion was filed earlier in the day than was the caveat, then there is no warrant for the action taken by the office.

We suggest that an examination of the books in the Examiner's, Mr. Moore's and the chief clerk's rooms, be made with a view of determining this question.

We can say that our application was filed early in the day on Feb'y 14, and at our request was on the same day sent to the Examiner; we also call attention to the fact that our client's oath of invention is dated Jan'y 20, '76.

Respectfully,

POLLOK & BAILEY, *Atty's.*

EXAMINER'S ROOM 118, Feb'y 24, 1876.

Respectfully referred to the Hon. Commr. for instructions. The regular practice in the office has been to determine dates of filing by *days alone*, and in accordance with such practice I suspended the application herein referred to on a/c of a caveat, the application and caveat being filed upon the same day, viz., Feb'y 14, 1876.

In view of the practice above noted, I have paid no attention to the alleged difference between the times of the filings on same day.

Respectfully submitted,

Z. F. WILBER, *Ex'r.*

The application in order to become liable to suspension to await the completion of his application by a caveator must have been filed "within the year" of the life of the caveat. Ordinarily the day of filing is not computed, and is considered *punctum temporis*. Yet where justice requires it, the exact time in the day when an act was done may be shown by proof. (Kent's Comm. 95, n.) The Examiner will be guided by this rule in the present case, and if the record shows that the application was filed earlier in the day, then the caveat should be disregarded, and otherwise not.

ELLIS SPEAR,

Acting Commissioner.

25, 2, '76.

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Ex'r's Room 118, Feb'y 25, 1876.

The cash blotter in the chief clerk's room shows conclusively that the application was filed some time earlier on the 14th than the caveat.

The app'n was received also in 118 by noon of the 14th, the caveat not until the 15th.

Z. F. WILBER, *Ex'r.*

Copy sent,
Feb. 25.
S. R. A.

Examiner's Room, No. 118,
U. S. Patent Office,
Washington, D. C., Feb'y 25, 1876.

A. G. Bell,
Care Pollok & Bailey, *Present.*

Telegraphy, Feb'y 14, 1876.

The suspension of this application having been declared under a misapprehension of appt.'s rights, is withdrawn.

Z. F. WILBER, *Ex'r.*

IN THE MATTER OF THE APPLICATION OF A. GRAHAM BELL, FOR A PATENT FOR IMPROVEMENTS IN TELEGRAPHY, FILED FEB'Y 14, 1876.

In this matter amend the specification as follows: —

Page 2, erase from line 19 to line 24 inclusive, and substitute therefor the following: —

[In a pending application for Letters Patent, filed in the U. S. Patent Office February 25, 1875, I have described two ways of producing the intermittent current, the one by actual make and break of contact, the other by alternately increasing and diminishing the intensity of the current, without actually breaking the circuit; the current produced by the latter method I shall term, for distinction sake, a pulsatory current.

My present invention consists in the employment of a vibratory or undulatory current of electricity, in contradistinction to a merely intermittent or pulsatory current, and of a method of and apparatus for producing electrical undulations upon the line wire.

The distinction between an undulatory and a pulsatory current will be understood by considering that electrical pulsations are caused by sudden or instantaneous changes of intensity, and that electrical undulations result from *gradual* changes of intensity exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations. The electrical movement, like the aerial motion, can be represented by a sinusoidal curve, or by the resultant of several sinusoidal curves.

Intermittent or pulsatory and undulatory currents may be of two kinds, accordingly as the successive impulses have all the same polarity, or are alternately positive and negative.]*

Page 13, line 15, after "synonymously" [insert and in contradistinction to the terms "intermittent" and "pulsatory."†]

In the 4th claim, erase the word "alternately" whenever it occurs, and substitute therefor the word ["gradually."‡]

POLLOK & BAILEY,
Atty's for A. GRAHAM BELL.

Copied
Mar. 26, '78.

Room. No. 118. (*No.* 14.) (*Interference.*)

INTERFERENCE A.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

158
58

WASHINGTON, D. C., Mar. 26, 1878.

Also copy to

A. G. BELL,
Care A. POLLOK, *Present.*

GARDINER G. HUBBARD,
Cambridge, Mass.

---

* Amdt. A, Feb. 29, '76. † Amdt. B, Feb. 29, '76. ‡ Amdt. C, Feb. 29, '76.

3514

Please find below a copy of a communication from the Examiner concerning your patent No. 174,465, dated Mar. 7, 1876, for telegraphy.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications and patents named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the sixth day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is "The hereinbefore described art of transmitting and reproducing at a distance sonorous waves or vibrations of any description, which consists in increasing and decreasing the strength of an electric current traversing a circuit in such a manner as to produce in said circuit a series of electrical waves or vibrations precisely corresponding in their intervals of succession and relative amplitudes to the sonorous waves which are to be reproduced at the receiving station or stations, so that oral conversations or sounds of any description may be telegraphically transmitted." (Gray's first claim.)

This is substantially the method specified in Bell's fifth claim, and is described in the applications of Edison, Berliner, Richmond, Dolbear and Holcombe.

PARTIES TO INTERFERENCE.

Elisha Gray, App'n filed Oct. 29, 1877. (No. 1.) Att'ys of Record, Baldwin, Hopkins and Peyton, Washington, D. C.

Thos. A. Edison, App'n filed Apr. 27, 1877. (Case 130.) Att'y of Record, L. W. Serrell, Box 4,689, New York City.

Emile Berliner, App'n filed June 4, 1877. Att'y of Record, James L. Norris, Washington, D. C.

Geo. B. Richmond, App'n filled Aug. 24, 1877. Att'y of Record, George W. Dyer, Washington, D. C.

3515

A. G. Holcombe, App'n filed Jan. 28, 1878. Att'y of Record, Moses G. Farmer, Torpedo Station, Newport, R. I.

A. E. Dolbear, App'n filed Oct. 31, 1877. (A.) Att'y of Record, Frank L. Pope, Elizabeth, N. J. Jas. L. Norris, Asso. Att'y Washington. D. C.

H. C. TOWNSEND, *Ex'r.*

Copy,
Mar. 25, 1878.
P. W. P.
Room No. 118. (*No.* 14.) (*Interference.*)

INTERFERENCE B.

158
58

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., March 26, 1878.

Also copy to

ALEXR. G. BELL,
Care A. POLLOK, *Present.*

GARDINER G. HUBBARD,
Cambridge, Mass.

Please find below a copy of a communication from the Examiner, concerning your patent 174,465, dated March 7, 1876. "Telegraphy."

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the sixth day of May, 1878, with the subject of invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is the hereinbefore

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described improvement in the art of transmitting vocal sounds or spoken words telegraphically, which consists in throwing upon the line through the medium of a varying resistance electric impulses corresponding to the vibrations of a diaphragm operated by the movements of the air produced by a spoken word. (Gray's second claim.)

This is substantially described in the applications of Gray, Edison, Berliner and Richmond.

The parties to the interference are: Elisha Gray, app'n filed Oct. 29, 1877; atty's, Baldwin, Hopkins & Peyton, Washington, D. C. T. A. Edison, app'n filed April 27, '77 (case 130); att'y, L. W. Serrell, box 4,689, N. Y. City. Emile Berliner, app'n filed June 4, '77; att'y, Jas. L. Norris, Washington, D. C. Geo. B. Richmond, app'n filed Aug. 24, '77; att'y, Geo. W. Dyer, Washington, D. C.

H. C. TOWNSEND, *Exr.*

Two Copies.
Mar. 26, 1878.
P. W. P.
Room No. 118. (*No.* 14.) (*Interference.*)
158
58

INTERFERENCE C.—PATENT 174,465.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Mar. 26, 1878.

Also copy to

ALEX. G. BELL,
Care A. POLLOK, *Present.*

GARDINER G. HUBBARD,
Cambridge, Mass.

Please find below a copy of a communication from the Examiner concerning your patent No. 174,465, dated Mar. 7, '76.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

3517

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the sixth day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is: 1st. The transmitter, consisting of the combination in an electric circuit of a diaphragm and a liquid or equivalent substance of high resistance, whereby the vibrations of the diaphragm cause variations in the resistance of the electric circuit, and consequently in the strength of current traversing said circuit. (Gray's first claim.)

This is described in the applications of Richmond and Edison and patent of Bell.

2d. In a telegraph instrument operated by sound, the combination with the diaphragm of two or more electrodes placed in electrolytic liquid and operating to increase and decrease the resistance of the electric circuit, by the movement derived from the diaphragm. (Edison's first claim.)

This is described in the applications of Richmond and Gray, and is substantially suggested in Bell's patent.

The parties to this interference are: Elisha Gray, Dec. 4, '77 (No. 2); Baldwin, Hopkins & Peyton, Washington, D. C., Att'ys of Record. G. B. Richmond, app'n filed Aug. 24, '77; G. W. Dyer, Washington, D. C., att'y. T. A. Edison, app'n filed Sept. 5, '77 (case 144); L. W. Serrell, box 4,689, New York City, att'y.

H. C. TOWNSEND, *Ex'r.*

Copy, Mar. 26, 1878. *Room No.* 118. (*No.* 14). (*Interference.*)
P. W. P.

$\frac{1}{5}\frac{5}{8}\frac{8}{}$

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PATENT 174,465.—INTERFERENCE E.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Mar. 26, 1878.

Copy to send

ALEX. G. BELL, *Care* A. POLLOK, *Present.*

GARDINER G. HUBBARD, *Cambridge, Mass.*

Please find below a copy of a communication from the Examiner concerning your patent No. 174,465, dated March 7, '76.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is, in an acoustic telegraph an armature plate, the electro-magnet for the same, and a closed circuit passing from the helix of such electro-magnet to the source of undulatory electric energy.

This is the subject matter of Edison's third claim, and is substantially described in the other applications and the patent involved.

The parties to this interference are:—

T. A. Edison app'n filed Dec. 12, '77 (case 145);

L. W. Serrell, Box 4,689, N. Y. City, attorney.

A. E. Dolbear, app'n filed Oct. 31, '77;

F. L. Pope, Elizabeth, N. J., Att'y of Record, and Jas. L. Norris, Washington, D. C., associate.

Geo. B. Richmond, app'n filed Aug. 24, '77;

G. W. Dyer, Washington, D. C., att'y.

Elisha Gray, app'n filed Dec. 4, '77 (No. 3);
Baldwin, Hopkins & Peyton, Washington, D. C., att'ys.
A. G. Holcombe, app'n filed Jan. 20, '78;
M. G. Farmer, Torpedo Station, Newport, R. I., att'y.

H. C. TOWNSEND, *Ex'r.*

Copy sent
Mar. 26, 1878.
L. S. R.
Room No. 118. (*No.* 14.) (*Interference.*)
158
58

PATENT 174,465. — INTERFERENCE F.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., March 26, 1878.

Also copy to

A. G. BELL,
Care A. POLLOK, *Present.*

GARDINER G. HUBBARD,
Cambridge, Mass.

Please find below a copy of a communication from the Examiner, concerning your patent, No. 174,465, dated March 7, '76, "Telegraphy."

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the sixth day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope.

The subject matter involved in the interference is a telephonic

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transmitter, consisting of a coil of wire, one or more magnets, and a disc or diaphragm, so arranged relative to each other that a motion of the diaphragm shall induce in the coil of wire an electric motive force in virtue of the presence of the magnet or magnets.

This is substantially Holcombe's first claim, and is described and shown in applications of Dolbear and Gray, and patent of Bell.

The parties to this interference are: —

A. G. Holcombe, app'n filed Jan. 28, '78;

M. G. Farmer, Torpedo Station, Newport, R. I., attorney.

A. E. Dolbear, app'n filed Oct. 31, '77; F. L. Pope, Elizabeth, N. J., att'y, and J. L. Norris, Washington, D. C., associate.

Elisha Gray, app'n filed Oct. 29, '77 (No. 1); Baldwin, Hopkins & Peyton, Washington, D. C., att'ys.

H. C. TOWNSEND, *Ex'r.*

Copy sent
Mar. 26, 1878.
L. S. R.

Room No. 118. (*No.* 14.) (*Interference.*)

INTERFERENCE G.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

$\frac{158}{58}$

WASHINGTON, D. C., Mch. 26, 1878.

Also copy to

A. G. BELL,
Care A. POLLOK, *Present.*

GARDINER G. HUBBARD,
Cambridge, Mass.

Please find below a copy of a communication from the Examiner concerning your patent for telegraphy, No. 174,465, dated Mar. 7, 1876.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

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Your case above referred to is adjudged to interfere with applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the sixth day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is a telephonic, receiver consisting of the combination in an electric circuit of a magnet and a diaphragm supported and arranged in close proximity thereto, whereby sounds thrown upon the line may be reproduced accurately as to pitch and quality (substantially Gray's claim.)

This is substantially covered by Holcombe's second claim, and is described or shown in the applications of Richmond, Dolbear, Edison and McDonough, and in patent of Bell.

PARTIES TO INTERFERENCE.

Elisha Gray, App'n filed Dec. 4, 1877 (No. 3); Baldwin, Hopkins & Peyton, Washington, D. C., Att'ys of Record.

Geo. B. Richmond, App'n filed Aug. 24, 1877; G. W. Dyer, Washington, D. C., Att'y of Record.

A. E. Dolbear, App'n filed Oct. 31, 1877; F. L. Pope, Elizabeth, N. J., Att'y of Record; J. L. Norris, Washington, D. C., Asso. Att'y.

T. A. Edison, App'n filed Dec. 24, 1877; (No. 148), L. W. Serrell, Box 4,689, New York City, Att'y of Record.

A. G. Holcombe, App'n filed Jan. 28, 1878; Moses G. Farmer, Torpedo Station, Newport, R. I., Att'y of Record.

James W. McDonough, App'n filed Apr. 10, 1876; Gridley & Sherburne, Chicago, Ill., Att'y of Record.

A. G. Bell, Pat. No. 174,465, dated Mar. 7, 1876; A. Pollok, Washington, D. C., Att'y of Record.

H. C. TOWNSEND, *Ex'r.*

Copy made
Mar. 26, 1878.
J. H. M.

Room No. 118. (*No.* 14.) (*Interference.*)

$\frac{158}{58}$

18

3522

INTERFERENCE H.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Mch. 26, 1878.

Also copy to

A. G. BELL, *Care* A. POLLOK, *Present*

GARDINER G. HUBBARD, *Cambridge, Mass.*

Please find below a copy of a communication from the Examiner concerning your Pat. No. 174,465, dated Mar. 7, 1876,

"Telegraphy."

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is the combination in one circuit of two or more coils of wire, two or more magnets, and two or more discs or diaphragms, so arranged relatively to each other that if one of the discs or diaphragms be put in motion by the voice, by a current of air or otherwise, it shall induce a transient current of electricity in its associated coil, which current shall actuate the other discs or diaphragms in virtue of the coils and magnets associated with them. (Holcombe's third claim.)

This is described and shown in applications of Dolbear and Gray, and patent of Bell.

PARTIES TO INTERFERENCE.

A. G. Holcombe, App'n filed Jan. 28, 1878;

Moses G. Farmer, Torpedo Station, Newport, R. I., Att'y of Record.

Elisha Gray, Appn filed Oct. 29, 1877 (No. 1);
Baldwin, Hopkins & Peyton, Washington, D. C., Atty's of Record.
A. E. Dolbear, App'n filed Oct. 31, 1877;
F. L. Pope, Elizabeth, N. J., Att'y of Record;
J. L. Norris, Washington, D. C., Asso. Att'y.

H. C. TOWNSEND, *Ex'r.*

Copy,
Mar. 25, 1878.
P. W. P.
Room No. 118.

(*No.* 14.)
Patent 174,465.

(*Interference.*)

INTERFERENCE L.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

158
58

WASHINGTON, D. C., Mar. 26, 1878.

Also copy to

ALEXR. G. BELL,
Care A. POLLOK, *Present.*

GARDINER G. HUBBARD,
Cambridge, Mass.

Please find below a copy of a communication from the Examiner concerning your patent, No. 174,465, dated Mar. 7, '76. "Telegraphy."

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the sixth day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is: 1st. The combination in an acoustic telegraph of an electro-magnet, and a polarized armature formed of a plate of iron, steel or other material capable of

3 35244

inductive action, and a resonant tube or case. (Edison's first claim.)

2d. The combination in an acoustic telegraph of an armature plate polarized by induction, a resonant case or tube, and an electro-magnet and circuit connections, whereby reverse currents are caused to act in the electro-magnet with varying intensity proportionate to the electric waves sent from the transmitting station. (Edison's second claim.)

This subject matter is described and shown in the applications of Edison and Gray.

The parties to this interference are: T. A. Edison, app'n filed Dec. 13, '77 (case 145); L. W. Serrell, box 4,689, N. Y. City, Att'y of Record. Elisha Gray, app'n filed Jan. 17, '78; atty's, Baldwin, Hopkins & Peyton, Washington, D. C.

H. C. TOWNSEND, *Ex'r.*

Copied.
Room No. 3.

DEPARTMENT OF THE INTERIOR.
UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Dec. 26, 1878.

BEFORE THE PRIMARY EXAMINER.

IN RE-INTERFERENCE BELL *v.* GRAY ET AL.

Subject Matter: Telephony.
Cases from A to L.

A. G. BELL,
Care A. POLLOK, *Present.*

ELISHA GRAY,
Care BALDWIN, HOPKINS & PEYTON, *Present.*

A. G. HOLCOMBE,
Care M. G. FARMER,
Torpedo Station, Newport, R. I.

AMOS E. DOLBEAR,
Care JAS. L. NORRIS, *Present.*

GEO. B. RICHMOND,
Care GEO. W. DYER, *Present.*

EMILE BERLINER,
Care A. POLLOK, *Present.*

THOS. A. EDISON,
Care L. W. SERRELL,
P. O. Box, 4,689, *N. Y. City.*

JAS. W. McDONOUGH,
Care GRIDLEY & SHERBURNE,
Chicago, Ill.

3525

The motion made on behalf of Bell to dissolve and reform these interferences is denied by the Primary Examiner.

In the absence of any appeal from this decision within one week from date, these cases will be returned to the Examiner of Interferences, and proceedings looking to the determination of the question of priority will be resumed.

H. C. TOWNSEND, *Ex'r.*

Copied.
Room No. 118.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Dec. 30, 1878.

BEFORE THE PRIMARY EXAMINER.

IN RE INTERFERENCE, BELL *vs.* GRAY ET AL.

Subject Matter, Telephony.
Cases, A to L.

A. G. BELL,
Care A. POLLOK, *Present.*

ELISHA GRAY,
Care BALDWIN, HOPKINS & PEYTON, *Present.*

A. G. HOLCOMBE,
Care M. G. FARMER,
Torpedo Station, Newport, R. I.

AMOS E. DOLBEAR,
Care JAS. L. NORRIS, *Present.*

GEO. B. RICHMOND,
Care GEO. W. DYER, *Present.*

EMILE BERLINER,
Care A. POLLOK, *Present.*

THOS. A. EDISON,
Care L. W. SERRELL,
P. O. Box, 4,689, *N. Y. City.*

JAS. W. MCDONOUGH,
Care GRIDLEY & SHERBURNE,
Chicago, Ill.

The limit of appeal from the decision of the Primary Examiner upon Bell's motion is extended to Jan'y 4, 1879.

H. C. TOWNSEND, *Ex'r.*

3526

MEMORANDUM OF FEE PAID AT U. S. PATENT OFFICE.

Inventor,
A. G. BELL.
Patent to be issued to
"
Invention.
Telegraphy.
Date of Payment,
Mch. 4th, '76.
Final
Fee,
$20.
Solicitors,
POLLOK & BAILEY,
Present.

1876, *Wilber* $\frac{158}{68}$
No. 174,465.

ALEXANDER GRAHAM BELL.

Of Salem,
County of
State of Mass.

TELEGRAPHY.

Rec'd Feb. 14, 1876.
Petition, " "
Affidavit, " "
Specification, " "
1 Drawing 2 sheets, " "
Model not required.
Cert. dep.
1 Cash $15. Feb. 14, 1876.
Add'l Fee Cert.
" " Cash $20. Mch. 4, 1876.
Examined March 3d 1874, Wilber.
2 Issue March 3, '76, Knight, M.
4 Patented Mch. 7, 1876.
Circular Mch. 3, 1876.

POLLOK & BAILEY,
Present.

3527

1876.

CONTENTS.

		Application, 1 paper.	
	1	Letter, Feb. 19, 1876.	
	2	Appt's Protest, Feb'y 24, 1876.	
	3	Office Letter, " 25, "	
	4	Amend^{ts}. A. C., Feb. 29, 1876.	
	5	Briefed March 3d, 1876.	
A.	6	Int'f $\times\frac{116}{73}$, $\frac{72}{64}$, $\frac{86}{12}$, $\frac{104}{58}$, $\frac{118}{1}$, $\frac{135}{90}$.	Mar. 26, 1878.
B.	7	Int'f. $\times\frac{116}{73}$. $\frac{72}{64}$. $\frac{86}{12}$, $\frac{104}{58}$.	Mar. 26, 1878.
C.	8	Int'f. $\times\frac{116}{72}$, $\frac{104}{58}$. $\frac{107}{15}$.	Mar. 26, 1878.
E.	9	Int'f. $\times\frac{126}{48}$, $\frac{118}{1}$, $\frac{104}{58}$, $\frac{116}{71}$, $\frac{135}{90}$.	Mar. 26, 1878.
F.	10	Int'f. $\times\frac{135}{90}$, $\frac{118}{1}$, $\frac{11}{73}$.	Mar. 26, 1878.
G.	11	Int'f. $\times\frac{116}{71}$, $\frac{104}{58}$, $\frac{118}{1}$, $\frac{128}{85}$, $\frac{135}{90}$, $\frac{176}{32}$.	Mar. 26, 1878.
H.	12	Int'f. $\times\frac{135}{90}$, $\frac{118}{1}$, $\frac{116}{73}$.	Mar. 26, 1878.
I.	13	Int't. $\times\frac{126}{48}$, $\frac{133}{54}$.	Mar. 26, 1878.
	14		
	15		
	16		
	17		
	18		

TITLE.

Improvement in Telegraphy.

Ex. J. A. W.
M. McK.

3258 COMPLAINANTS' EXHIBIT NO. 37, BELL'S TORONTO DRAWING.

(RECORD, PAGE 498.)

Complainants Exhibit 37.
Bell Toronto Drawing.
W. J. Peckham Examiner.

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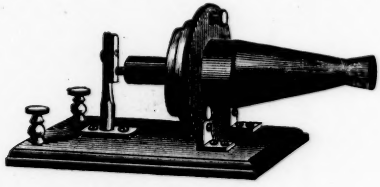
COMPLAINANTS' EXHIBIT NO. 38, BELL'S SINGLE POLE CENTENNIAL MEMBRANE TELEPHONE.

(RECORD, PAGE 497.)



DIMENSIONS.

Length of cone	$5\frac{3}{4}$	inches.
Diameter of membrane	3	"
Length of spool	$1\frac{3}{4}$	"
Diameter of spool	$1\frac{3}{8}$	"

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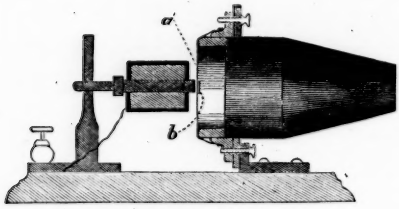
COMPLAINANTS' EXHIBIT NO. 38, BELL'S SINGLE POLE CENTENNIAL MEMBRANE TELEPHONE. (Sectional View.)

(RECORD, PAGE 497.)

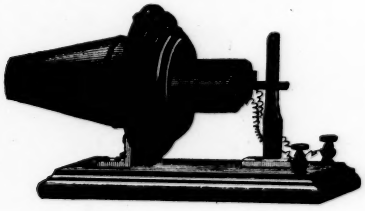


a Stretched Membrane.
b Steel Spring Armature.

3531

COMPLAINANTS' EXHIBIT NO. 39, BELL'S DOUBLE POLE CENTENNIAL MEMBRANE TELEPHONE.

(RECORD, PAGE 497.)



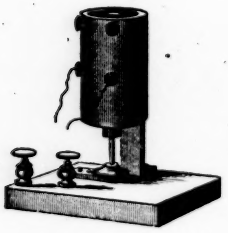
DIMENSIONS

Length of cone	$4\frac{3}{4}$	inches.
Diameter of membrane	3	"
Length of spools	$1\frac{3}{4}$	"
Diameter of spools	$1\frac{3}{8}$	"

3512

COMPLAINANTS' EXHIBIT NO. 40, CENTENNIAL IRON BOX MAGNET RECEIVER.

(RECORD, PAGE 497.)



DIMENSIONS.

Diameter of tube	$1\frac{3}{4}$ inches.
Length of tube	3 "

3533

COMPLAINANTS' EXHIBIT NO. 41, BELL'S CENTENNIAL LIQUID TRANSMITTER.

(RECORD, PAGE 497.)

DIMENSIONS.

Diameter of membrane	3	inches.
Diameter of cup	$\frac{3}{4}$	"
Depth of cup	$\frac{1}{2}$	"
Length of cone	6	"

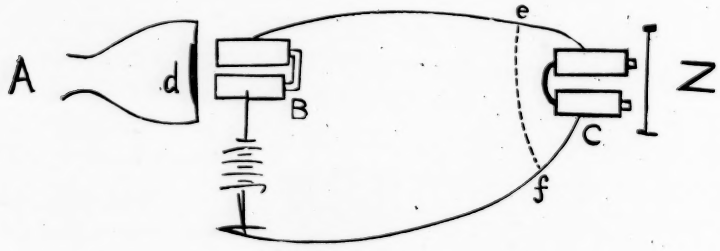
3534

COMPLAINANTS' EXHIBIT 42, BELL'S MEMORANDA OF EXPERIMENTS OF 1876. W. P. PREBLE, JR., EXAMINER.

[RECORD, PAGE 501.]

JUNE 30, 1876.

Returned from Philadelphia Exhibition, last Monday.



Two magnets B and C have been made for experiments upon real lines. The resistance of B is 1,650 ohms, and C has a resistance of 1,600 ohms. A is ordinary telephone. The membrane has a small piece of very thin sheet iron (Tagger's iron), attached to it. Z is a flat disk of Tagger's iron.

I tried the instruments this morning with four carbon cells. I could not obtain any indications of attraction. Upon placing my ear at Z, however, I could hear a click when the circuit was broken. When Wilson sang into A, I could hear the sound of the voice at Z.

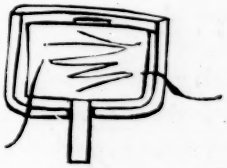
Upon breaking the circuit at C, the sounds were inaudible at Z. No sounds were heard at Z, when a wire connected *e* and *f*. The sounds of Eddie Wilson's voice were reproduced by Z, when there was only *one* cell on the circuit. This is most extraordinary, especially when we consider that the resistance of the magnets alone is equivalent to 3,250 ohms, or 320 miles of well-insulated telegraph wire. It is probable that the sounds proceed from Z when no battery is on the circuit, and that the inductive power of *d*, acting upon the residual magnetism of B, creates an undulatory current in C. I fancied I could hear faint sounds from Z when no battery was on the circuit, but other noises were loud, and besides, I could hear Eddie's voice through the air, although very faintly.

2. When Eddie Wilson sang to Z, faint sounds were audible from A. Four cells on circuit.

JULY 3d, 1876.

1. Williams made magnet for me like that shown in Fig. 1. The resistance of the coil is 1,800 ohms.

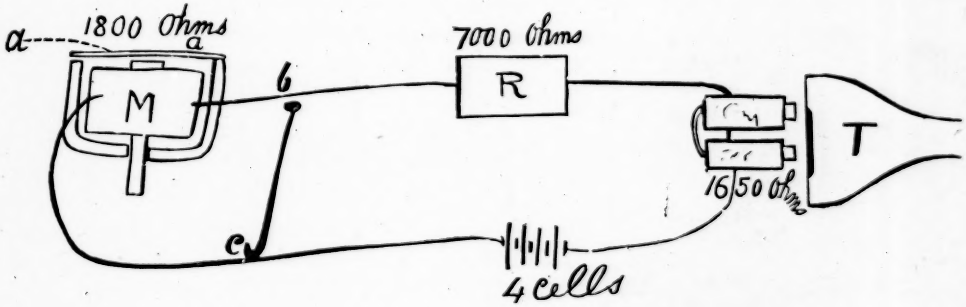
FIG. 1.



2. The instrument shown in Fig. 1 was connected upon circuit with a telephone as in Fig 2, and resistance inserted as at R, Fig. 2.

Four cells of a carbon and bichromate battery were employed. As the total resistance of the circuit was equivalent to 10,450 ohms, the battery had an inappreciable effect upon the magnetism of M. The steel spring

FIG. 2.



armature *a* was not sensibly attracted by M, and yet sounds uttered into T were heard proceeding softly from *a* of M. The sounds were inaudible from *a* when a piece of copper wire was laid from *b* to *c*.

Noted by A. G. B., July 3d, 1876.

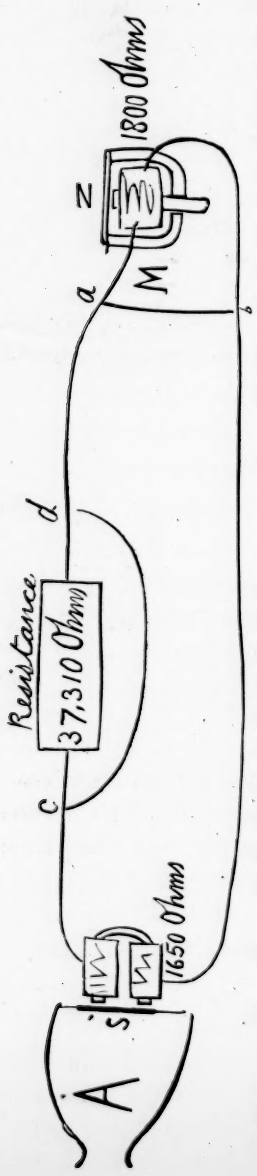
THURSDAY, July 6th, 1876.

1. Instruments arranged as in Fig. 2, page 17 [page 77 of print], battery power gradually reduced to one cell.

The sound emitted by *a* of M was little inferior in loudness to that heard when four cells were employed. It seems extraordinary that the vibration of a little piece of iron weighing a few grains

should cause an audible sound upon a circuit of 10,450 ohms resistance with only one cell of battery. There can be no doubt that the sounds are electrically produced, although Edward Wilson's voice could be heard through the air also; for when Edward Wilson prolonged his sounds, they were audible through the air, so ————. But upon listening at A, the sound was broken up so —————— when the magnet M was cut off from the circuit by tapping with the wire *b c* upon the point *b*.

FIG. 3.



2. The battery was entirely removed from the circuit, and the rheostat (R, Fig. 2, page 17) disconnected.

When E. Wilson sang into T, the sounds were audible from *a* of M.

FRIDAY, July 7th, 1876.

5. A third rheostat (the largest in the store, containing a total resistance of 21,100 ohms) was introduced into the circuit, so that the total resistance interposed at R was 37,310 ohms. The sounds proceeding from Z were perfectly plain, and were very slightly diminished in intensity. The difference in intensity, however, was very marked when the cut-off *a b* was used. No sound was audible when the cut-off *b c* was employed. (See Fig. 2.)

Total resistance of circuit equals 40,760 ohms.

6. No further resistance being obtainable, it was decided to reduce the battery power.

The battery was reduced from ten cells to one cell, and still sounds were audible from Z (Fig. 2), very slightly fainter than when 10 cells were employed.

7. Upon removing the battery altogether, as in Fig. 3, sounds were still perfectly audible from Z. No sounds were audible from M when

(*a*) The armature Z was removed;

(*b*) When the circuit was broken;

(*c*) Or when the cut-off *a b* was employed.

The sounds were much louder when the cut-off *c d* was used so as to cut out the resistance.

All these facts convinced me and Mr. Watson that the sounds audible at Z were electrically produced, and were not merely mechanically conducted along the wire. And yet it seems almost too marvellous for belief that the vibration of a little piece of thin iron S, weighing only a few grains, should induce electrical undulations upon a circuit of 40,760 ohms resistance (a greater resistance than from here to England) so as to have the vibration reproduced at Z. After such an experiment as the above, I feel confident that we shall be able to transmit vocal sounds through the *cable, and this, too, without a battery.*

TUESDAY, July 11th, 1876.

Tried improved apparatus at Williams to-day with great success. Tried varying the shape of the armature attached to the membrane.

FIG. 1.

S is the armature with which I have hitherto experimented. It was attached to the membrane M. S^1 is the new armature, consisting of a disk of thin Tagger's iron almost as large as the membrane M^1 to which it was attached.

Two instruments were arranged, one with the armature S, the other with the armature S^1, and the audible effects compared.

They were alternately arranged upon circuit with the receiver M, as shown in Figure 2 (page 22). The transmitters were in the attic of Mr. Williams' building and the receiver M in the basement.

Ten cells of a carbon battery were employed, and artificial resistance R to the amount of 16,210 ohms introduced into the circuit. When the instrument having the armature S′ (Figure 1, page 21) was used, the sounds proceeding from Z (Figure 2, page 22) were immensely louder than when the instrument with the armature S was employed.

2. When the armature S′ was used, conversation in an ordinary tone of voice was perfectly audible at the receiving instrument. Indeed, the softer the initial articulation, the more distinct was the utterance at the other end of the line.

When the initial utterance was loud, the final articulation was also loud but indistinct, and when the voice at the transmitting end was raised scarcely above a whisper, the sounds at the receiving end were very faint but were perfectly distinct. The total resistance of circuit was 19,660 ohms.

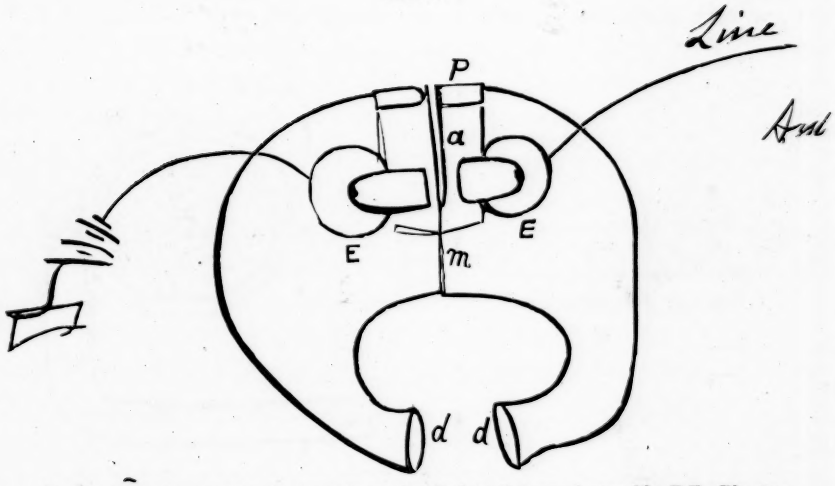
Noted by A. G. B.

WEDNESDAY MORNING, July 12, 1876.

THOUGHTS.

1. Try the effect (*a*) of varying the size of the armature attached to the membrane.
   (*b*) Vary the *mass*, use thick pieces of iron attached to a sounding board.
   (*c*) Use small electro-magnets as the armatures attached to sounding board.
   (*d*) Vibrate the electro-magnet instead of the armature.
   (*e*) Have arrangement similar to Siemen's polarized relay — see Fig. 1.

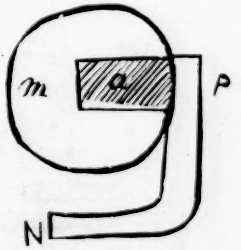
FIG. 1.



P. Permanent magnet; A. Armature attached to the membrane M; E E. Electro-magnet; *d d.* Double ear-trumpets.

FIG. 2.

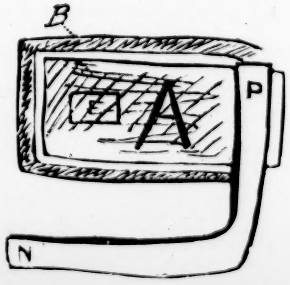
SIDE VIEW OF ARMATURE AND MEMBRANE.



P. N. Permanent magnet.
m. Membrane.
a. Armature.

FIG. 3.

SIDE VIEW OF PROPOSED ARMATURE WITHOUT MEMBRANE.

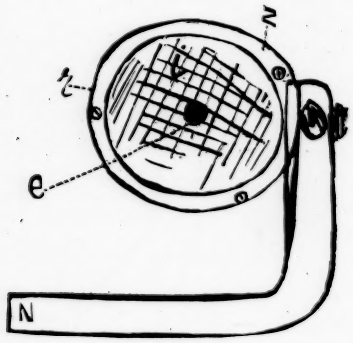


P. N. Permanent magnet.
A. Armature arranged in a bed (B) similar to a free reed.
E. One of the poles of the electro-magnet employed.

3540

ANOTHER FORM OF POLARIZED ARMATURE WITHOUT ANY MEMBRANE (SIDE VIEW).

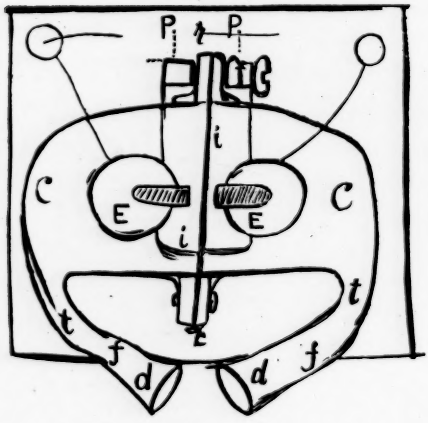
FIG. 4.



i. Tagger's iron.
r. Rim of soft iron.
P N. Permanent magnet.
e. Pole of electro-magnet.

PLAN OF INSTRUMENT SHOWN IN FIG. 4.

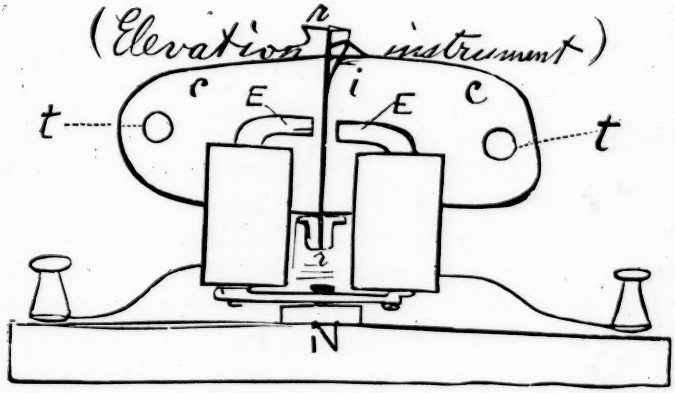
FIG. 5.



P P. Pole of permanent magnet.
r. Soft iron rim.
i. Tagger's iron.
E. Poles of electro-magnet.
c. Metallic casing enclosing the whole instrument.
T. Metallic tubes.
f. Flexible piping.
d. Double ear-trumpets.

3541

FIG. 6.



The lettering is the same in Figs. 4, 5, 6.
Noted, A. G. B., July 12, 76.

MONDAY, Oct. 2d, 1876.

Upon reading a few of the records in the second volume of my electrical experiments, I was struck by an experiment made July 11 (page 27), which I had quite forgotten. Why we have relinquished the improved form of armature shown in Fig. 1, page 27 (2d vol.), I cannot think. Shall repeat the experiment. It will be a good plan to repeat all the earlier experiments, with the improved receivers we now have.

Noted Oct. 14, 1876, by A. G. B.

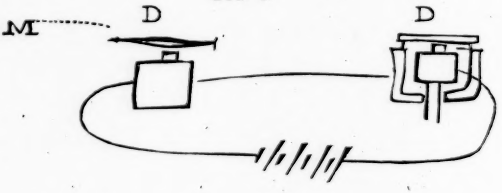
OCT. 2 TO OCT. 7th, 1876.

The experiments have been irregularly conducted during this week, and have not been noted in consequence of omission to procure a new book. We are convinced of the very great importance of noting every experiment at the time it is made, as the remembrance so soon fades away. A number of experiments made during the last few days have been forgotten.

3 3542

Experiment referred to above (Monday, Oct. 2), was tried during the week. The large armature was found to be infinitely superior to the small one employed. A large disk of thin steel was glued to the membrane M, and Mr. Watson spoke with his mouth almost in contact with D, condensing his breath by means of his hands.

FIG. 1.



I listened at D′. The articulation was much more distinct than any heard yet. I then spoke with my mouth against D′, and Mr. Watson listened at D, and the articulation was intelligible. We then held the following conversation. I think this was on Saturday, the 7th of October.

BELL TO WATSON. — If you understand what I say, say something to me.

WATSON TO BELL. — It is (decidedly) the best I ever saw.

BELL TO WATSON. — It is the best *I* ever heard.

WATSON TO BELL. — Success at last has (*attended*) our efforts.

BELL TO WATSON. —

> " Let us then be up and doing,
> With a heart for any fate.
> Still untiring, still pursuing,
> Learn to labor and to wait."

Noted by A. G. B, Oct. 14, 1876.

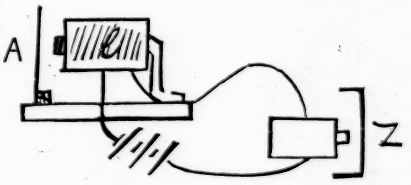
Thursday, OCT. 12, to Sunday, Nov. 12.

Systematic notation of experiments during this month has been almost impossible on account of many circumstances, specially because I have been out of town, in the evening at Cambridge and at Bradford, and have been professionally engaged during the day. Mr. Watson's absence in Philadelphia for one week, and subsequent illness from typhoid fever, interrupted experiments, and what little

time I could spare from professional duties, latterly have been devoted to writing a specification of a patent to send to England. I shall note here now the principal experiments made during the month : —

1. The success of enlarging the steel armature of the telephone (see page 5), led me to think of dispensing with the membrane altogether. A disk of thin steel A (Fig. 2) about six inches in diameter was fastened in front of the electro-magnet *e*. On speaking to *A* the articulation was heard from *Z*, much more distinctly than we had heard before.

FIG. 2.



2. The following facts have been conclusively proved by our experiments with the form of apparatus shown in Fig. 2, page 5 : —

1. That the sounds audible from the receiving instrument are loudest when the speaker condenses the air against membrane by means of his hand.

2. That the sounds from the receiving instrument are most distinct when the speaker speaks against the same side of the membrane on which the electro-magnet is placed.

3. That the articulation is most distinct when the membrane is omitted, and a simple plate of steel used as in Fig. 2, page 15.

4. That the audibility of the sounds depends upon the resistance of the electro-magnets of the transmitting and receiving telephones. The greater the resistance of the coils the better the effect, the current being supposed of the same mean intensity throughout.

3. Arrangements have been made with Prof. Rogers for experiments between Exeter Place and Cambridge Observatory, and a line has been erected connecting me with the Boston and Cambridge circuit, at the office of Messrs. George & Stearns, Electricians, No. 39 Pearl St., on Friday morning, the 10th of November. Mr. Greenough and Mr. ——, of the Boston Gas Works, as well as Mr. George, were present at the Pearl St. end of the line. The instruments used were those shown in Fig. 3.

4. Instruments shown in Fig. 3 were constructed somewhere about the 19th or 20th of October, before Mr. Watson left for Philadelphia, and they are still the instruments preferred. The electro-magnet is placed in a box B of wood. The front of the box was then cut away, and a sheet of thin steel A screwed on to it by screws *s*, *s*, *s*, *s*. A hole H was left in the top of the box for the purpose of speaking into. Two instruments were made and arranged upon circuit as in Fig. 4. Upon speaking into the hole H, Fig. 3, the voice was heard very loudly from the the other telephone, but indistinctly.

FIG. 3.

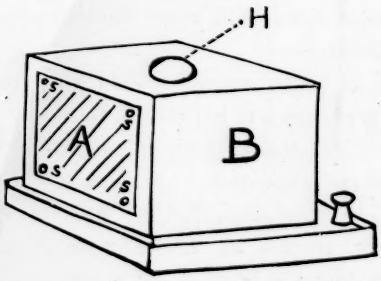
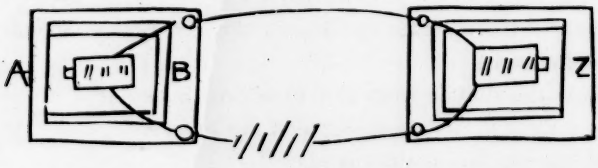


FIG. 4.



Upon placing the mouth against the plate and A speaking, the sounds became perfectly distinct from the other telephone. Upon condensing the air against the armature A by means of the hand, the utterance was perfectly distinct and quite as loud as when we spoke into the hole H.

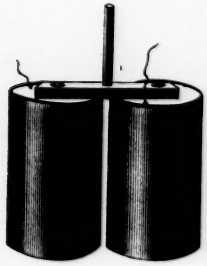
When we blew against A, Fig. 4, the sound was audible at *Z*.

Noted A. G. B., Sunday, Nov. 12, 1876.

3545

COMPLAINANTS' EXHIBIT NO. 43, BELL'S PERMANENT MAGNET OF 1876.

(RECORD, PAGE 502.)



DIMENSIONS.

Diameter of spool	$1\frac{5}{8}$	inches.
Length of spool	3	"
Length of core	3	"
Diameter of core	$\frac{1}{2}$	"

COMPLAINANTS' EXHIBIT 44. BELL'S ENGLISH PROVISIONAL SPECIFICATION, W. P. PREBLE, JR., EXAMINER.

[RECORD, PAGES 503 and 531.]

ELECTRIC TELEPHONY.

LETTERS PATENT to William Morgan-Brown, of the Firm of Brandon and Morgan-Brown, Engineers and Patent Agents, of 38, Southampton Buildings, London, and 1, Rue Lafitte, Paris, for the Invention of "IMPROVEMENTS IN ELECTRIC TELEPHONY (TRANSMITTING OR CAUSING SOUNDS FOR TELEGRAPHING MESSAGES) AND TELEPHONIC APPARATUS." A communication from abroad by Alexander Graham Bell, of the University of Boston, Massachusetts, United States of America, Professor of Vocal Physiology.

Sealed the 15th May, 1877, and dated the 9th December, 1876.

PROVISIONAL SPECIFICATION left by the said William Morgan-Brown at the Office of the Commissioners of Patents on the 9th December, 1876.

A. D. 1876, 9th DECEMBER. No. 4,765.

WILLIAM MORGAN-BROWN, of the firm of Brandon and Morgan-Brown, Engineers and Patent Agents, of 38, Southampton Buildings, London, and 1, Rue Lafitte, Paris. "IMPROVEMENTS IN ELECTRIC TELEPHONY (TRANSMITTING OR CAUSING SOUNDS FOR TELEGRAPHING MESSAGES) AND TELEPHONIC APPARATUS."

In all previous systems of telegraphy messages have been received either by means of chemical changes produced by the action of the electrical current, as in the various forms of automatic and autographical telegraphs, or by means of the mechanical movement of a portion of the receiving instrument operating to produce a visible signal, as in needle telegraphs, a mark upon paper or other material, as in printing telegraphs, or a sound, as in the Morse system. Upon these and all other plans it has been found difficult, if not

A.D. 1876. Dec. 9. Nº 4765.

MORGAN-BROWN'S Provisional Specification.

FIG. 11.

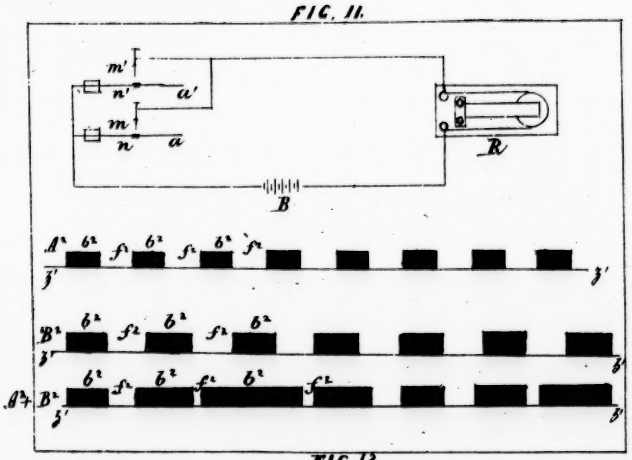


FIG. 12.

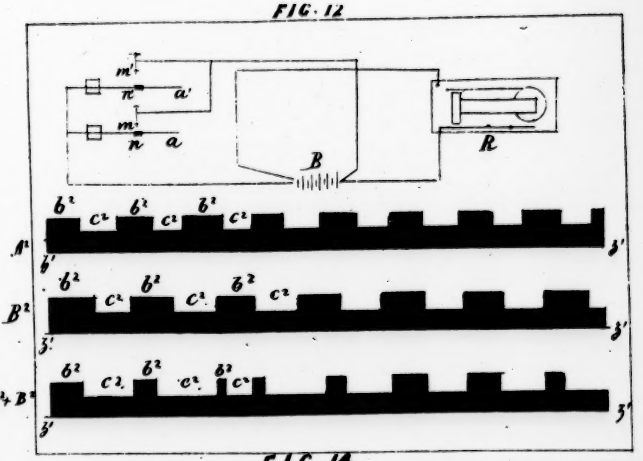


FIG 13.

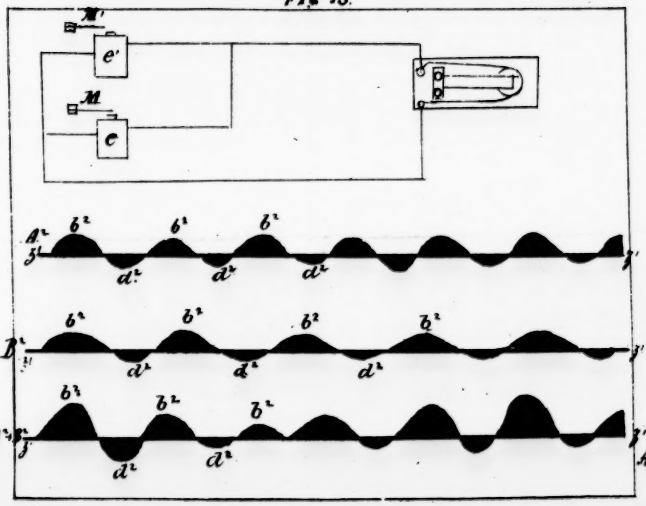
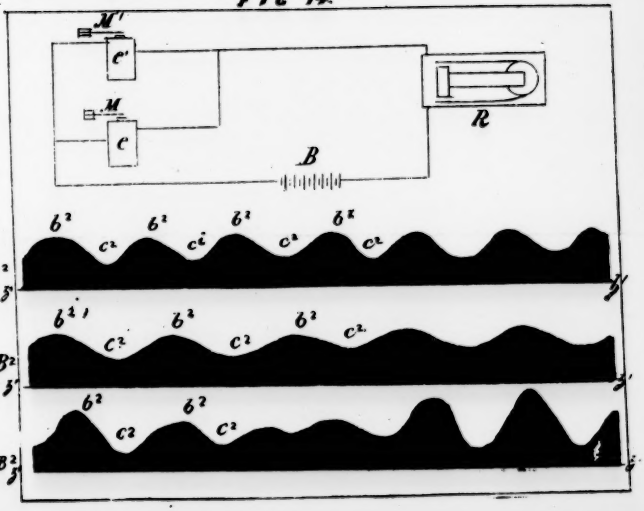


FIG 14.



2547

COMPLAINANTS' EXHIBIT 44. BELL'S ENGLISH PROVISIONAL SPECIFICATION, W. P. PREBLE, JR., EXAMINER.

[RECORD, PAGES 503 and 531.]

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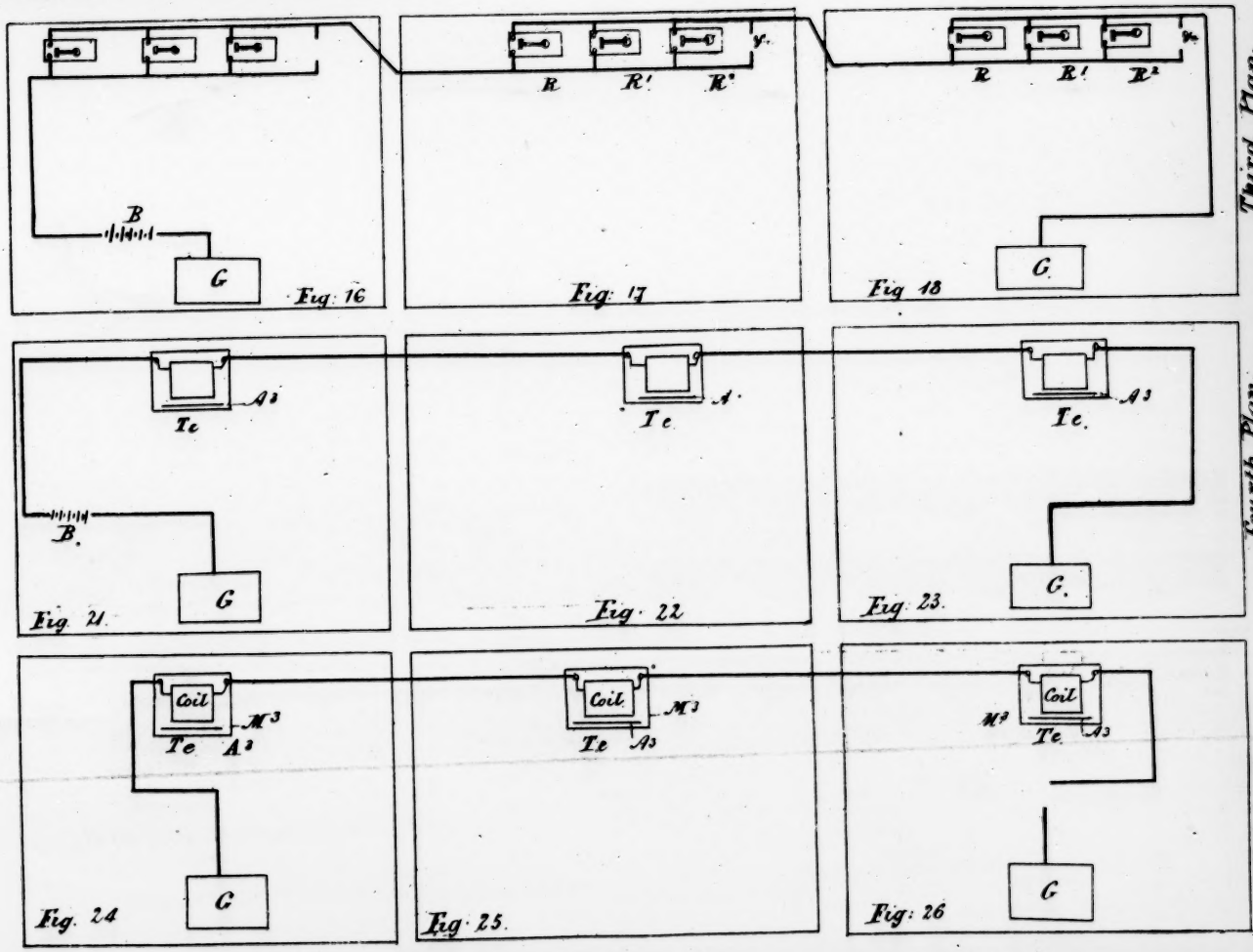
MORGAN-BROWN'S Provisional Specification.



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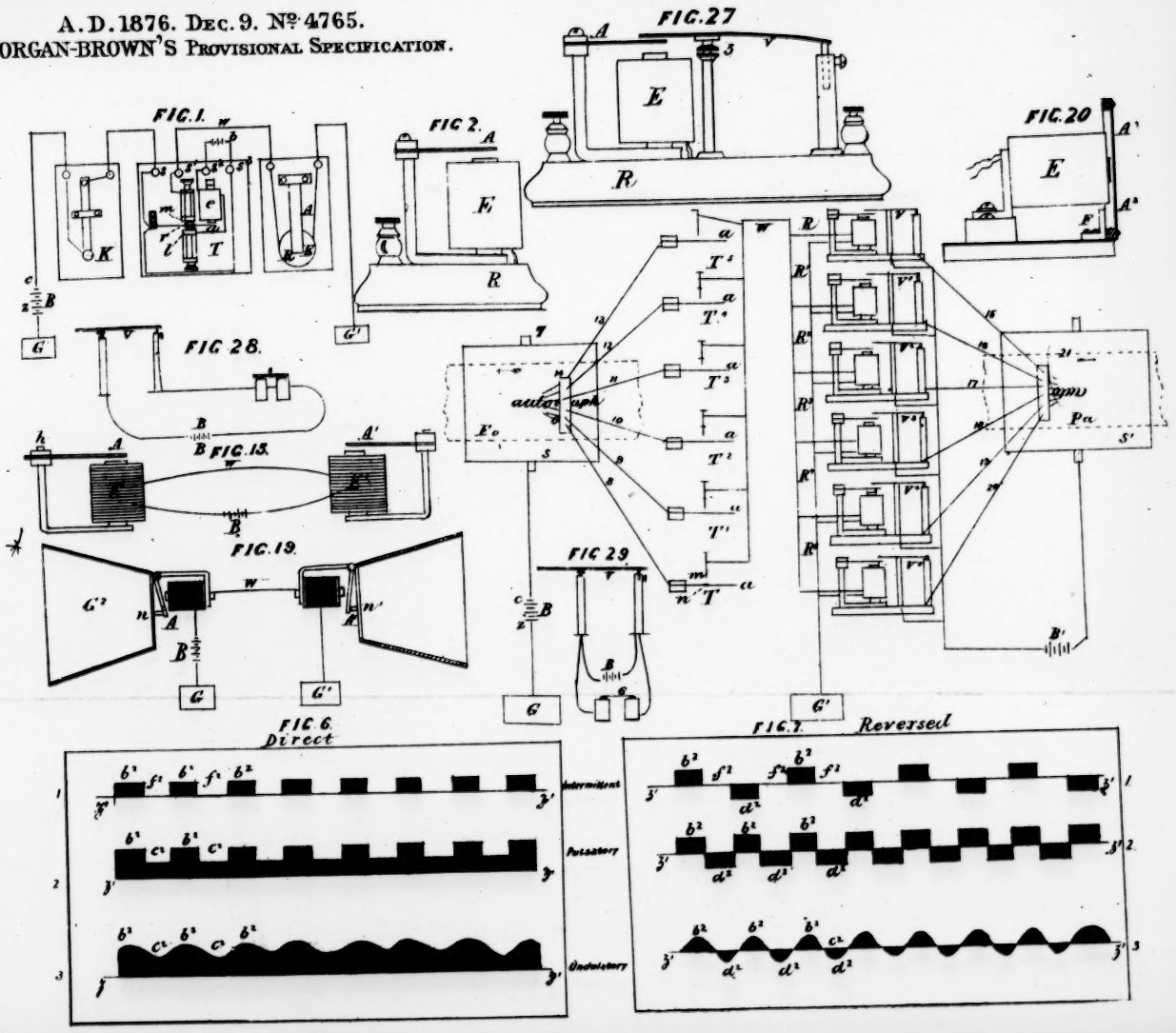
A.D. 1876. Dec. 9. Nº 4765.

MORGAN-BROWN'S Provisional Specification.



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MORGAN-BROWN'S Provisional Specification.

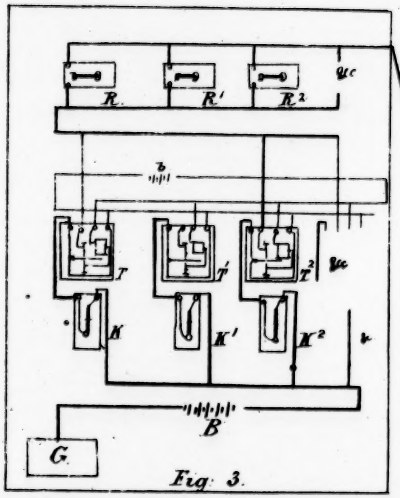

Fig. 3.

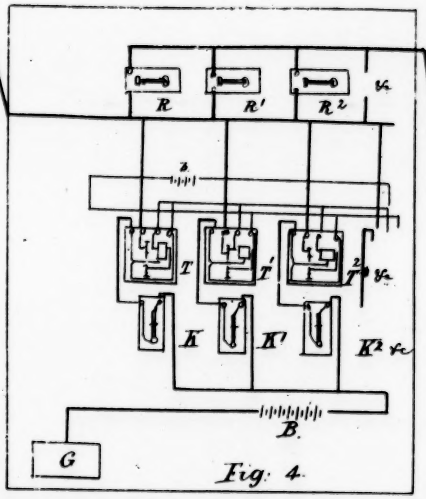

Fig. 4.

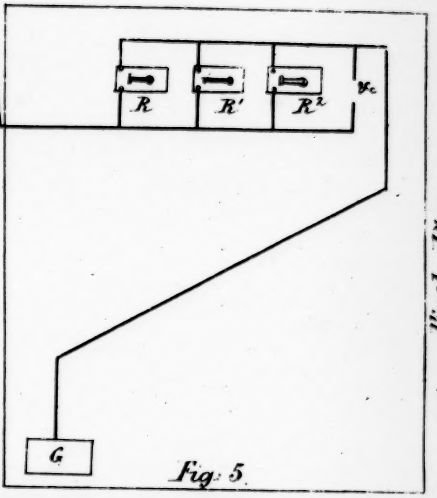

Fig. 5.

First Plan.

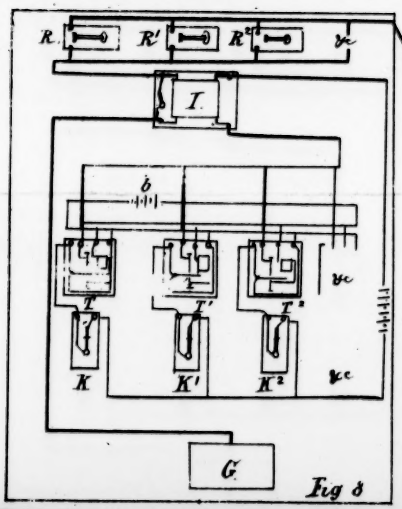

Fig 8

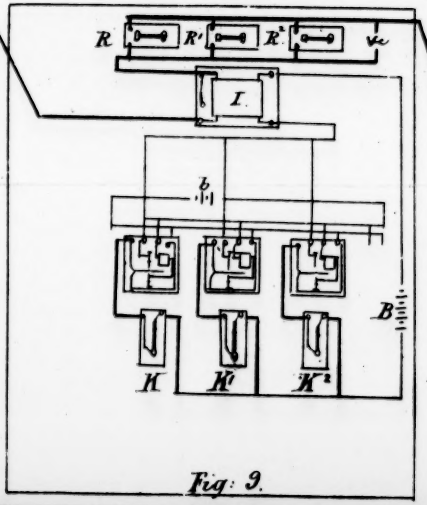

Fig. 9.

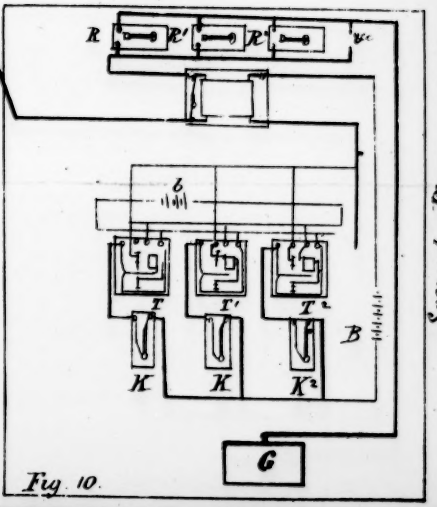

Fig. 10.

Second Plan.

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impossible, to distinguish between more than four messages transmitted simultaneously over the same circuit, two in each direction.

This present Invention relates to the reproduction by the necessary receiving instruments of any particular sounds or combination of sounds through the agency of an electric current, whereby a multiplicity of telegraphic messages may be sent simultaneously over a single circuit in the same or in opposite directions and received without confusion, and whereby articulate speech may be electrically transmitted.

The first part of the Invention relates to the production or transmission of musical notes by means of intermittent impulses of voltaic electricity, and to the utilization of such musical notes as telegraphic signals, whereby two or more telegraphic messages can be sent simultaneously in the same direction over a single circuit.

The second part of the Invention relates to the production or transmission of musical notes by means of intermittent impulses of induced electricity, whereby two or more telegraphic signals or messages can be sent simultaneously over a single circuit in the same or in opposite directions.

The third part of the Invention relates to the production or transmission of musical notes by means of undulatory currents of electricity, one battery being used for the whole circuit, whereby two or more telegraphic signals or messages can be transmitted simultaneously over a single circuit in the same or in opposite directions.

The fourth part of the Invention relates to the electrical production or transmission of sounds of every kind by means of undulatory currents of electricity, whereby not only musical sounds but articulate speech can be transmitted over a telegraph line, and two or more messages be simultaneously sent over a single circuit in the same or in opposite directions.

The fifth part of the Invention relates to the electrical production or transmission of sounds of every kind, without a battery, by means of undulatory currents of electricity, whereby not only the musical notes but articulate speech can be transmitted over a telegraph line, and two or more messages be sent simultaneously over a single circuit in the same or in opposite directions.

The sixth part of the Invention relates to the automatic reception

of signals or messages by introducing at the receiving end of the line a local circuit containing a vibratory circuit breaker, whereby telephonic signals or messages may be automatically recorded.

The seventh part of the Invention relates to the application of electric telephony to autographic telegraphy, whereby characters or marks of any description may be copied in *fac-simile* at the receiving end of the line.

First Plan.

The first part of the Invention (illustrated in Figures 1 and 2 of Sheet 1, and Figures 3, 4, and 5 of Sheet 2) consists of a method of and apparatus for transmitting two or more telegraphic messages or signals simultaneously along a single wire by the employment of transmitting instruments, each of which occasions a succession of electrical impulses differing in rate from the others; and of receiving instruments each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting instruments.

The transmitting instrument T (Figure 1) consists of an electro-magnet e having a steel spring armature a, which is kept in continuous vibration by the action of a local battery b; the armature a in the course of its vibration brings the platinum rivet r alternately into contact with two platinum points l and m, one, l, being placed in a local circuit b, s^2, e, l, r, s^3, b, and the other, m, communicating with the line wire W through the screw cap s^1.

The receiving instrument R, shewn in plan in Figure 1, and in elevation in Figure 2, consists of an electro magnet E, having a coil upon only one of its legs. A steel spring armature A is firmly clamped by one extremity to the uncovered leg of the electro-magnet E, and its free end is allowed to project above the pole of the covered leg. Upon depressing the key K (Figure 1) a communication is established between the main battery B and the vibrating armature a of the transmitter T. When the rivet r touches the point m the main circuit is completed, the currents of z passed to the ground at G, and the currents of c pass through K, s, r, m, s^1, to the line wire W, and thence through the electro-magnet E of the receiver R to the ground at G^1. When the rivet r leaves the point

m the main circuit is broken. So long then as the key K is depressed the vibration of *a* occasions an intermittent action of the current from the battery B upon the line wire W, and the armature A of the receiver R is attracted in an intermittent manner by its electro-magnet E.

When the makes and breaks of the circuit at *m*, *r*, are timed to the normal movements of the armature A of the receiving instrument, that is, when A is tuned to yield the same musical pitch as the armature *a* of the transmitting instrument, then the armature A is thrown into strong vibration, thereby causing it to emit its musical note.

When the key K is raised, the communication between the main battery B and the transmitter T is cut off, and A becomes silent. So long as the key K is depressed, a musical note is emitted by A, and the duration of this note can be made to signify the dot or dash of the Morse alphabet. Thus a telegraphic despatch can be sent from T to R by manipulating the key K in the usual manner.

Figures 3, 4, and 5, Sheet 2, illustrate the combination of these instruments upon a telegraphic circuit, so as to permit of the simultaneous transmission of a number of telegraphic messages along a single wire.

The armatures of the transmitters and receivers that are numbered alike at all the stations have the same pitch. Thus the transmitter T^2 of Figure 3 is the unison of the transmitter T^2 at the station represented in Figure 4, and also of the receiver R^2 at the stations shewn in Figures 3, 4, and 5.

The sounds produced by the transmitters T, T^1, T^2 &c., differ in pitch from one another, and are so arranged that each transmitter can affect one and one only of the receiving instruments R, R^1, R^2 &c., at each station upon the line.

To illustrate the operation of this form of the Invention, depress any key, say, key K^1, Figure 3, a communication being thereby established between the main battery B and the transmitting instrument T^1, an intermittent current passes on to the main line through the receiving instruments R, R^1, R^2, &c., of Figures 3, 4, and 5, to the earth at G, Figure 5. The receiving instruments R^1, Figures 3, 4, and 5, respond so long as the key K^1, Figure 3, is depressed,

and become silent the moment it is raised. The other instruments R, R^2, &c., at stations Figures 3, 4. and 5, remain silent, so that a telegraphic message transmitted by the manipulation of key K^1, Figure 3, is received upon only its corresponding receiving instrument at each station toward that station herein shown as Figure 5, where the receiving instruments are connected directly with the earth.

The instruments shewn in Figure 4, operate as just described for those of Figure 3, the depression of each key K, K^1, or K^2, &c., operating those receiving instruments in stations 4 and 5 that are in unison with the transmitting instrument connected with the key, but does not affect the instruments in Figure 3, or in that direction.

To illustrate the simultaneous transmission of telegraphic messages by these instruments, an operator in the station, shown in Figure 3, is supposed to manipulate the key K, while at the same time another operator in station Figure 4 is transmitting an entirely different despatch by the manipulation of the key K^1. The signals produced by the depression of key K, Figure 3, are received by the receivers R of Figures 3, 4, and 5, and the signals due to the manipulation of the key K^1, Figure 4, affect the receiving instrument R^1 of Figures 4 and 5, but not R^1 of Figure 3, or of any station in the direction of Figure 3, hence, although upon this plan two or more messages may be sent simultaneously over the same circuit from the same or different stations to the same or different stations, still as the signals pass only in one direction, two line wires are required to complete communication in both directions. Intermittent currents adapted to work these instruments, may be produced without actually making and breaking the circuit, as hereinbefore described, by suddenly increasing and diminishing the intensity of the current. Such currents are termed for the sake of distinction "pulsatory." Intermittent and pulsatory currents may be of two kinds, accordingly as the electrical impulses have all the same polarity, or are alternately positive and negative; in the former case they are termed "direct," in the latter "reversed" currents. These distinctions are graphically illustrated in Figures 6 and 7.

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Second Plan.

In order to secure communication in both directions upon a single circuit, the second portion of this Invention was devised, and it is illustrated in Figures 8, 9, and 10. In these Figures the instruments employed are similar to those shown in Figures 1, 2, 3, 4, and 5, and like instruments are denoted by like letters, but instead of connecting the transmitting instruments T, T^1, T^2, &c., directly with the receiving instruments R, R^1, R^2, &c., as in Figures 3, 4, &c., they are connected with the primary wires of an induction coil I, of usual construction, and the currents induced in the secondary wires of the coil are directed to the receiving instruments R, R^1, R^2, &c., on the line wire. By this arrangement the receiving instruments at the terminal stations Figures 8 and 10 are connected directly with the earth at G, and signals made at any one station appear at all the stations on the circuit. On this plan therefore two or more messages may be sent simultaneously over a single circuit in the same or in opposite directions.

Third Plan.

In the methods heretofore described employing intermittent currents of electricity the limit to the number of signals that can be sent simultaneously over the same wire is very speedily reached; for when a number of transmitting instruments having different rates of vibration are simultaneously making and breaking the same circuit, the effect upon the main line is practically equivalent to one continuous current; in addition to this objection local and main batteries are required at every station on the line. Similar difficulties are experienced in employing pulsatory currents; to obviate these difficulties, the plan of using an undulatory current of electricity as described in this third part of the invention was devised.

It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet, a current of electricity is induced in the coils of the latter, and that when it is made to recede a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front

of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond in rapidity of succession to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration, or rather to the velocity of its motion. A current of this character is graphically represented in line 3, Figure 7, Sheet 1. When the permanent magnet is caused to vibrate in front of the pole of an electro-magnet which is placed in circuit with a voltaic battery, the undulatory current induced by the vibration of the permanent magnet is superposed upon the voltaic current. When the induced impulse is of similar polarity to the voltaic current it serves to strengthen the intensity of the latter, but when it is of opposite polarity it tends to neutralize the voltaic current. In such an arrangement the resultant effect of the vibration of the permanent magnet is to throw the battery current into waves, as in line 3, Figure 6, by alternaterly increasing and diminishing the intensity of the current. Such increase and diminution in the intensity of the current does not take place with the suddenness characteristic of a pulsatory current (see line 2, Figure 6), but is proportional to the increase and diminution of the density of the air during the vibration of the inducing body.

The various kinds of electrical currents denominated intermittent, pulsatory, and undulatory, are graphically represented in Figures 6 and 7. In Figure 6 the currents are direct, that is, the electrical impulses b^2, b^2, b^2, &c., are all of the same polarity, either positive or negative, and in Figure 7 the currents are "reversed," that is the electrical impulses are alternately positive and negative.

Direct Intermittent Current (shewn in line 1, Figure 6).—The impulses b^2, b^2, &c., are all of positive or all of negative electricity, and the vertical thickness of the lines b^2, b^2, &c., measured from the zero line z^1, z^1, represents the intensity of the current at the part observed. The horizontal extention of the line b^2 indicates the duration of the electrical impulse, and the horizontal extention of the space f^2 shews the length of time the current is absent from the circuit.

Reversed Intermittent Current (shewn in line 1, Figure 7).—Impulses of positive electricity are represented above, and impulses

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of negative electricity below the zero line z^1, z^1, and the impulses b^2, d^2, are respectively positive and negative, or *vice versa*.

Direct Pulsatory Current (shewn in line 2, Figure 6). — The current of electricity represented is continuous, but it changes suddenly in intensity, the elevations b^2, b^2, &c., indicating the impulses of maximum intensity, and the depressions c^2, c^2, the impulses of minimum intensity. As before, the vertical thickness of the line indicates the strength of the current.

Reversed Pulsatory Current (shewn in line 2, Figure 7).— The impulses b^2, d^2, are alternately positive and negative without any break in the continuity of the current.

Direct Undulatory Current (shewn in line 3, Figure 6).— As before, the vertical thickness of the line represents the strength of the current, the elevations b^2, b^2, &c., express the impulses of maximum intensity, and c^2, c^2, &c., those of minimum intensity. The changes of intensity, as illustrated in line 3, do not occur with the suddenness characteristic of pulsatory currents, as shewn in line 2, but are proportional to the changes in the density of the air during the production of a sound.

Reversed Undulatory Current (shewn in line 3, Figure 7).— The elevations b^2, b^2, &c., indicate impulses of positive, and the depressions d^2, d^2, impulses of negative electricity, the vertical thickness of the portions b^2, d^2, indicating the intensity of the positive or negative impulse at the part observed. The oscillations of the current above and below the zero line correspond to the increase and diminution of the density of the air during the production of a sound, hence the elevations b^2, b^2, &c., correspond to condensations of air, and the depressions d^2, d^2, &c., to rarefactions, the intensity of the positive or negative impulses being proportioned to the degree of density or rarity of the air.

The differences between intermittent, pulsatory, and undulatory currents will be more clearly understood by describing and illustrating the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously, first upon one plan and then upon the others, let the interval between the two sounds be a major third; then their rates of vibration are in the ratio of 4 to 5. Now, when an intermittent current is used, the circuit is made and

broken 4 times by the armature a, Figure 11, Sheet 1, of one transmitting instrument in the same time that 5 makes and breaks are caused by the armature a^1 of the other transmitting instrument. A^2 and B^2, Figure 11, represent the intermittent currents produced, four impulses of B^2 being made in the same time as five impulses of A^2; b^2, b^2, &c., Figure 11, shew where and for how long a time the circuit is made, and f^2, f^2, &c., indicate the duration of the breaks of the circuit. The line $A^2 + B^2$ shews the total effect upon the current when the armatures a, a^1, Figure 11, are caused simultaneously to make and break the same circuit, and the combined effect upon the current passing through the receiver R, shewn at $A^2 + B^2$, Figure 11, is very nearly equivalent to a continuos current.

When many transmitting instruments of different rates of vibration are simultaneously making and breaking the same circuit the current upon the main line become for all practical purposes continuos.

When the armatures a, a^1, are arranged upon circuit, as shewn in Figure 12, pulsatory currents traverse the coils of the receiving instrument R. The line A^2 represents the pulsatory current due to the action of one armature a; and the line B^2, the action due to the other armature a^1; b^2, b^2, &c., represent impulses of maximum intensity; and c^2, c^2, &c., impulses of minimum intensity. Four impulses of B^2 are made in the same time as five impulses of A^2, and the line $A^2 + B^2$ represents the total effect upon the current passing through the coils of the receiver R, when the armatures a and a^1 are caused to vibrate simultaneously. This effect is nearly equivalent to a continuous current of mimimum intensity.

Next, consider the effect when undulatory currents are employed. Electrical undulations induced by the vibration of a body M, Figure 13, capable of inductive action, can be represented graphically by the same sinusoidal curve which expresses the vibration of the inducing body itself, for, as above stated, the rate of oscillation in the electrical current is the same as that of the inducing body. The intensity of each induced impulse is proportional to the velocity of the motion of the inducing body, and the polarity of each induced impulse depends upon the direction of the motion of the inducing body to or from the pole of its electro-magnet. The sinusoidal

curves A^2 and B^2, Figure 13, represent graphically the electrical undulations induced in a circuit by the vibration of permanent magnets M and M^1 or other bodies capable of inductive action.

The portions b^2, b^2, &c., represent impulses of positive electricity; and d^2, d^2, &c., impulses of negative electricity. The horizontal line z^1, z^2, represents the zero of current, and the vertical distance of any portion of the curve b^2 or d^2 from the zero line expresses the intensity of the positive or negative impulse at the part observed.

The vibrations represented by the sinusoidal curves B^2 and A^2, Figure 13, are in the ratio aforesaid of four to five; that is, four oscillations of B^2 are made in the same time as five oscillations of A^2.

The combined effect of A^2 and B^2 when induced simultaneously on the same circuit is expressed by the curve $A^2 + B^2$, Figure 13, which is the algebraical sum of the sinusoidal curves A^2 and B^2. In Figure 14 the permanent magnets M and M^1 are caused to vibrate in front of the poles of electro-magnets e, e^1, placed in circuit with a battery B. By such an arrangement the battery current is thrown into waves. The lines A^2, B^2, represent the undulatory currents produced respectively by the vibrations of M and M^1, and as in the instances four impulses of B^2 are made in the same time as five impulses of A^2, the elevations b^2, b^2, indicate impulses of maximum intensity, and the depressions c^2, c^2, &c., impulses of minimum intensity. The vertical distance of any portion of the curve b^2, c^2, from the zero line z^1, z^1, expresses the intensity of the current at the part observed. The line $A^2 + B^2$ expresses the resultant effect upon the current when the permanent magnets M, M^1, are caused to simultaneously vibrate. The curves $A^2 + B^2$, Figures 13 and 14, also indicate the actual motion of the air when the two magnets M, M^1, are vibrated simultaneously. Thus, when electrical undulations of different rates are simultaneously produced upon the same circuit, the effect is exactly analogous to that occasioned in the air by the vibration of the inducing bodies; hence the coexistence upon a telegraphic circuit of electrical undulations corresponding to sounds of different pitch is manifested, not by the obliteration of the vibratory character of the current, as with intermittent and pulsatory current, but by peculiarities in the shapes of the electrical undula-

tions, or in other words, by peculiarities in the shapes of the curves which represent those undulations.

There are many ways of producing undulatory currents of electricity dependent for effect upon the vibration or motion of bodies capable of inductive action. A few of the methods that may be employed are as follows: — When a wire, through which a continuous current of electricity is passing, is caused to vibrate in the neighbourhood of another wire, an undulatory current of electricity is induced in the latter. When a cylinder, upon which are arranged bar magnets, is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet.

Undulations are caused in a voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration of the conducting wire itself in the neighbourhood of such bodies. Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit or by alternately increasing and diminishing the power of the battery. The internal resistance of a battery is diminished by bringing the voltaic elements nearer together and increased by placing them farther apart. The reciprocal vibration of the elements of a battery therefore occasions an undulatory action in the voltaic current.

The external resistance may also be varied; for instance, let water or some other liquid of high resistance form part of a voltaic circuit, then the more deeply the conducting wire is immersed in the water or other liquid the less resistance does the liquid offer to the passage of the current. Thence the vibration of the conducting wire in water or other liquid included in the circuit occasions undulations in the current. The vertical vibration of the elements of a battery in the liquid in which they are imursed produces an undulatory action in the current by alternately increasing and diminishing the power of the battery.

In illustration of one method of creating electrical undulations a form of apparatus is shewn in Figure 15. It is preferable to employ for this purpose an electro-magnet E, Figure 15, having a coil upon only one of its legs. A steel spring armature A is firmly clamped by one extremity to the uncovered leg *h* of the magnet, and its free

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end is allowed to project above the pole of the covered leg. The armature A can be set in vibration in a variety of ways, one of which is by wind, and in vibrating it produces a musical note of a certain definite pitch.

When the electro-magnet E is placed in a voltaic circuit B, E, W, E^1, B, the armature A becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature A remains at rest no effect is produced upon the voltaic current, but the moment it is set in vibration to produce its musical note, a powerful inductive action takes place, and electrical undulations traverse the circuit above described. The undulatory current passing through the coil of the electro-magnet E^1 causes vibration in its armature A^1 when the armatures of the two magnets are normally in unison with one another, but the armature A^1 is unaffected by the passage of the undulatory current when the pitches of the two armatures are different.

The instruments shown in Figure 15 are like in plan to the receiving instruments R, R^1, &c., of Figures 1, 2, 3, 4, 5, 8, 9, 10. A number of instruments may be placed upon a telegraphic circuit, as in Figures 16, 17, 18. When the armature of any one of the instruments is set in vibration all the other instruments upon the circuit, which are in unison with it, respond, but those which have normally a different rate of vibration remain silent. Thus, if R, Figure 16, is set in vibration, the armature of the receivers R, Figures 17, 18, vibrate also, but all the others on the circuit remain still; so if R^1, Figure 17, is caused to emite its musical note the instruments R^1, shewn in Figures 16 and 18, respond. They continue sounding so long as the mechanical vibration of R^1, Figure 17, is continued, but becomes silent with the cessation of its motion. The duration of the sound may be used to indicate the dot or dash of the Morse alphabet, and thus a telegraphic dispatch may be indicated by alternately interrupting and renewing the sound.

When two or more instruments of different pitch are simultaneously caused to vibrate all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to only that instrument used as a transmitter, with which it is in unison. Thus the signals of R, Figure 16, are repeated by R of

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Figures 17 and 18, but by no other instrument upon the circuit; the signals of R^1, Figure 18, by R^1, Figures 16 and 17, and the signals of R^2, Figure 17, by R^2, Figures 16 and 18, whether R, Figure 16, R^1, Figure 18, and R^2, Figure 17, are successively or simultaneously caused to vibrate. Hence by these instruments two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another, a single battery B being used for the whole circuit. These instruments may be used for the simultaneous transmission of musical notes differing in loudness as well as in pitch.

When the armature A, Figure 15, is set in vibration the armature A^1 responds not only in pitch but in loudness. Thus, when A vibates with little amplitude a very soft musical note proceeds from A^1, and when A vibrates forcibly the amplitude of the vibration of A^1 is considerably increased and the resulting sound becomes louder; so if R and R^1, Figure 16, are sounded simultaneously (R loudly and R^1 softly) the instruments R, Figures 17 and 18, repeat loudly the signals of R, Figure 16, and R^1, Figures 17 and 18, repeat softly those of R^1, Figure 16.

Fourth Plan.

In the plans so far described a separate instrument is employed for every pitch, and the electrical vibrations for different pitches are combined upon the wire, each armature being capable of transmitting or receiving but a single note, and thus as many separate instruments are required as there are messages or musical notes to transmit.

In this fourth part of the Invention a single instrument is employed, the armature of which can be set in vibration by a musical instrument, or by the tones of a human voice, or by any sound whatever.

This fourth plan is represented in Figures 21, 22 and 23, wherein is shewn a single telephone at each station in place of the transmitting and receiving instruments heretofore described, the telephones being illustrated separately in Figures 19 and 20.

One of the ways in which the armature A, Figure 15, may be set in vibration has been stated to be by wind. Another mode is shewn

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in Figure 19, whereby motion can be imparted to the amature by the human voice, or by means of musical instrument, or by sounds of any kind.

The armature A, Figure 19, is fastened loosely by one extremity to the uncovered leg *h* of the electro-magnet E, and its other extremity is attached to the centre of a stretched membrane *n*. A cone C^2 is used to converge sound vibrations upon the membrane. When a musical note is made in the neighborhood of the membrane *n* it is set in vibration, the armature A is forced to partake of the motion, and thus electrical undulations are created upon the circuit G, B, E, W, E^1, G^1. The armature A^1 is thus thrown into synchronous vibration with the armature A, emitting a musical note of similar pitch to that which originated the vibration of armature A. If two or more musical notes be simultaneously sounded in the neighborhood of the cone C^2 the resultant motion of the air is copied by the membrane *n* to which the armature A is attached, and this armature A acting inductive by upon the current traversing the coils of the electro-magnet E occasions an increase and diminution in its utensity, and the armature A^1 is thrown into vibration by the varying attraction of the electro-magnet E^1 to which it is attached, and thus imparts to the air at n^1 a *facsimile* copy of the motion of the air that acted upon the membrane *n*; hence two or more musical notes or telegraphic messages can be sent simultaneously along a single circuit from one station to another by means of one instrument at each station.

Instead of the cone, membrane, and armature shewn in Figure 19, a plate of thin steel may be used, the vibrations of the plate in front of the magnet occasioned by the motion of the air during the production of sound changes the intensity of the current as hereinbefore described and occasions a similar motion in a similar steel plate in front of another electro-magnet at another station in the circuit. Such a plate is shewn in Figure 20, and marked A^3, it being attached to a frame F. The telephones shewn in Figures 21 to 26 are of the kind shewn Figure 20. This Invention is not limited however to the use of a steel plate, but includes within its scope any materials capable of inductive action upon a current of electricity. In this plan an operator at station, Figure 21, may send

a telegraphic message on a certain pitch, while another operator at another station, say, Figure 22, is transmitting another message on a different pitch, and both sounds will be audible at all the stations in the circuit.

The receiving operators will pay attention to signals of only one pitch, hence by this plan the simultaneous transmission of a number of telegraphic messages over a single circuit in the same or both directions with a single main battery for the whole circuit and a single telephonic instrument at each station is rendered possible. Whatever sound is made in the neighborhood of any telephone, say, T, *e*, Figure 21, is echoed in *facsimile* by the telephones T, *e*, of all the other stations, hence this fourth plan is also adapted for the entirely new use of transmitting intelligibly the exact sounds of articulate speech.

To convey an articulate message it is only necessary for the operator to speak in the neighborhood of a telephone, say T, *e*, Figure 21, and for the receiving operator at another instrument, say T, *e*, Figure 23, to listen.

If two persons speak simultaneously in the neighborhood of the same or different telephones, the utterances of the two speakers are reproduced simultaneously by all the other telephones on the same circuit, hence, by this plan vocal messages may be transmitted simultaneously over the same circuit in the same or opposite directions, with one battery for the whole circuit, and one telephone at each station on the line.

In this plan of transmitting vocal utterances it is only necessary that the strength of the current should vary in intensity as the air varies in density during the utterance of the sound.

All the methods of producing undulating currents of electricity hereinbefore described may be employed in producing the undulations by which to transmit articulate messages. For instance, the vibrations of a membrane may cause a platinum wire to vibrate in water or other liquid of high resistance included in the circuit, and hence will occasion changes in the intensity of the current traversing the circuit proportional to the changes in the density of the air which originally gave rise to the vibrations of the membranes, and hence

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the sounds uttered in the neighborhood of that membrane will be reproduced from a telephone on a distant part of the circuit.

In the fifth plan of the Invention, illustrated in Figures 24, 25, and 26, the battery is omitted, and a permanent magnet M^3 is substituted for the soft iron core of the electro-magnets used in the other telephones; or the coils shown in Figures 24, 25, and 26 may be induction coils of usual construction, local batteries being placed in circuit with the primary wires so as to magnetize the soft iron cores of the coils, the undulations induced in the secondary wires by the vibration of the plates A^3 being directed upon the line wire.

The sixth plan of the Invention is represented in Figures 27, 28, and 29, Figure 27 being a side view of a receiving instrument R, having a magnet E and armature, as before described, and provided also with a vibratory circuit breaker V; this circuit breaker is designed for the purpose of enabling the armature A to open or close a local circuit through the medium of the circuit breaker V; this circuit breaker consists of a light metallic lever nominally resting upon the point 5, preferably adjustable so as to close a local circuit. The extremity of the circuit breaker overhangs the free end of the armature A.

When the armature A is thrown into vibration by the action of magnet E, the circuit breaker in lifted from the point 5, and it does not return until the cessation of the vibration of the armature A.

In Figure 28 an arrangement is shewn whereby the lifting of the circuit breaker V opens a local circuit, in which is placed a Morse sounder 6 or other electrical apparatus.

In Figure 29 the circuit breaker V normally "short circuits" the battery B, cutting off the current from the Morse sounder 6, or other apparatus, so that the lifting of the circuit breaker V permits the current from the battery B to actuate the telegraphic instrument 6. The vibrating circuit breaker V may be changed in construction, it only being necessary that it have normally a slower rate of vibration than the armature A, by which it is vibrated.

Figure 30 represents an arrangement of transmitting instruments T, T^1, T^2, &c., and receiving instruments R, R^1, &c., and vibratory circuit breakers V, V^1, &c., similar to those shewn in Figures 1, 2, 27, designed to produce automatically at the receiving end of the

line a *facsimile* of whatever characters or marks are presented at the transmitting end. In this plan the messages or marks to be copied may be written or printed in non-metallic ink on a metallic surface F, *o*, shown in dotted lines (preferably tinfoil), or impressed upon the same; this metallic surface is placed upon a suitable metallic support S, preferably made as a roller, having its axis at 7 connected with the battery B and the earth G. At the receiving end a similar support S^1 is connected in circuit with a battery B^1 and the vibratory circuit breakers V, V^1, V^2, &c., and on this support is placed a piece or strip of chemically prepared paper P, *a*, shown in dotted lines.

The metallic surface F, *o*, on which is written the message to be transmitted, is moved between the support S and the ends of a series of wires 8, 9, 10, 11, 12, 13, &c., such ends being held by a non-metallic holder or bar 14. The wires 8, 9, 10, &c., communicate with the armatures *a* of transmitters T, T^1, &c., similar to the transmitter T, shewn in Figure 1. At the receiving end of the circuit the ends of a similar arrangement of wires 15, 16, 17, 18, 19, and 20 are held in place by a non-metallic holder 21, so as to rest upon the chemically prepared paper P *a*.

The metallic surface F, *o*, and the chemically prepared paper P, *a*, are each moved in the direction of the arrows under their respective series of wires, but not necessarily at equal speed, and the characters or marks on the foil are copied on the prepared paper.

When the end of any of the wires at the transmitting end, say wire 8, rests upon the metallic foil, a communication is established between the battery B and the armature *a* of the transmitter T, the platinum rivet *r*, as heretofore described, vibrates, and makes and breaks contact with the point *m*, so that an intermittent current of electricity appears upon the line wire W; so long then as the wire 8 rests on the metallic surface F, *o*, the currents of *c* pass through 7, S, F, *o*, 8, *r*, *m*, to the line wire W, and thence by branches through the receiving instruments R, R^1, &c., to the earth at G^1.

The armature of the receiving instrument R, which is in unison with the armature *a* of the transmitter T, is thrown into vibration by the passage of the intermittent current, but the armatures of the other transmitting instruments R^1, R^2, &c., having a different rate of vibration from the armature of T, do not respond.

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The armature of the receiving instrument R in the course of its vibration lifts the spring lever V, breaking the circuit B^1, S^1, P, *a*, 15, V, B^1; so long then as the end of the wire 8 rests upon the metallic surface F, *o*, the local circuit in which the wire 15 is placed remains open, and thus no mark is made upon the paper P, *a*, under wire 15.

When during the movement of the metallic surface F, *o*, a portion of the non-metallic ink comes under the end of the wire 8, the connection between the battery B and transmitter T is broken, the receiver R becomes silent, the spring lever V returns to its normal position, closing the circuit above described, and a mark is made upon that part of the chemically prepared paper P, *a*, under wire 15.

Each wire 9, 10, &c., operates in a like manner to the wire 8, and the wires 16, 17, 18, &c., operate as described for wire 15.

Any of the ordinary chemically prepared paper used in connection with ordinary systems of chemical or autograph telegraphs may be used.

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COMPLAINANTS' EXHIBIT NO. 45, BELL'S SPEAKING TELEPHONE METALLIC DIAPHRAGM.

(RECORD, PAGE 504.)

DIMENSIONS.

Diameter of diaphragm . . . . . 5 inches.

COMPLAINANTS' EXHIBIT 46.

[EXTRACT BELL'S PRELIMINARY STATEMENT IN HARMONIC INTERFERENCE.] W. P. PREBLE, JR., EXAMINER

[RECORD, PAGE 533.]

During the summer of 1874, doubts occurred as to the operation of the induced current. When the primary circuit of an induction coil is closed a momentary impulse of positive electricity is induced upon the secondary circuit, and when it is opened an impulse of negative electricity appears upon the secondary wire. I feared that the induced current would be insufficient to set the armatures of the receiving instruments in vibration, unless the negative impulses came exactly midway between the positive impulses, and unless the armatures of the receiving instruments were rendered permanently magnetic, so as to be alternately attracted and repelled by their electro-magnets.

The thought occurred, of inducing the impulses by means of a permanent magnet instead of a battery.

When a permanent magnet is caused to approach the pole of an electro-magnet, a current of electricity is induced in the coils of the latter; and when it is made to recede, a current of opposite polarity to the first is induced in the electro-magnet. The vibration, then, of a permanent magnet in front of the pole of an electro-magnet, would produce an oscillating current in the coils of the latter, and the reversed impulses be at equal distances apart. The form which this idea took at this time (summer of 1874) is shown in Fig. 15. A B, A′ B′ are steel reeds attached to permanent magnets M M′, vibrated by wind in front of the poles of electro-magnets E E′. A and B were to be of different pitch, and A′ B′ to be their counterparts respectively. When A should be made to produce its musical note, A′ (its unison) would be thrown into vibration; for when A moved downwards, the current induced upon the circuit would cause the poles of the electro-magnet E′ to be of opposite polarity to A′ and B,′ and therefore A′ would be attracted downwards; but when A should move upwards, the polarity of E would be the same as A′, and therefore A would be repelled. As the normal rate of vibration

357°

of A′ coincides with that of A the former would respond to the latter's vibration, and *vice versa*, but neither B nor B′ be affected. Reflection led me to believe that this idea was very valuable, as the currents induced in the coils of the electro-magnets E E′ would correspond exactly to the effects produced in the air by the passage of a musical note. The polarity of each induced impulse would depend upon the direction of the motion of the permanent magnet A to or from the pole of the electro-magnet under it, and hence would correspond to a condensation or rarefaction of air. The succession of induced impulses would be at the same rate per second as the vibrations of A, hence would correspond to the pitch of the note produced; and the intensity of each impulse would depend upon the extent or amplitude of the vibrations of A, and would correspond to the loudness of the resulting note.

The idea gradually developed, that notes differing in loudness as well as pitch could be simultaneously transmitted, and, as a corollary, the feasibility of the transmission of the *timbre* or quality of a sound suggested itself; for, according to Helmholtz' theory the quality of a sound depends upon the simultaneous production of a number of musical notes differing from each other in pitch and loudness. In each sound the fundamental or lowest tone is the loudest, the overtones being comparatively weak and faint. The apparatus shown in Fig. 16 was conceived as a means of transmitting vocal utterance telephonically.

Steel rods were to be attached at one end to the poles N S of a permanent magnet M, as in Fig. 16. An electro-magnet E was to be placed between the two sets of rods H H. An exactly similar instrument H′ H′ was to be placed upon another part of the circuit.

Upon uttering a sound in the neighborhood of H, it was presumed that certain rods would be set sympathetically in vibration by the voice. The rod corresponding to the fundamental tone would vibrate forcibly and those corresponding to the overtones of the sound would respond faintly. Each rod, partaking of the polarity of the pole N or S to which it was attached, would induce in the coils of the electro-magnet E a series of electrical oscillations corresponding in rate per second to the number of its vibrations, and in intensity to the amplitude of its motion. The electrical impulses traversing

the coils of the electro-magnet E′ would cause vibrations in the corresponding rods H′ H′. The unison of the fundamental tone would respond loudly; and the rods corresponding in pitch to the overtones would vibrate feebly. Although the absolute loudness of all the sounds produced by the rods H′ H′ would be very faint, still the relative loudness of the notes would be preserved; and hence theoretically a repetition of the sound uttered in the neighborhood of H H should proceed from H′ H′.

Fearing that ridicule would be attached to the idea of transmitting vocal sounds telephonically, especially by those who were unacquainted with Helmholtz' experiments, I said little or nothing of this plan. Indeed, reflection convinced me that, however feasible the scheme looked upon paper, it was impracticable, as the induced currents would be far too feeble to overcome any great resistance. For the same reason the plan shown in Fig. 15 seemed impracticable save in theory; and I began to look about for some other method of inducing alternate positive and negative impulses, which should succeed each other at equal intervals of time; and at last I hit upon the plan of making and breaking contact by means of a revolving cylinder, as shown in Fig. 17.

COMPLAINANTS' EXHIBIT NO. 47, BELL TELEPHONE OF 1875, DUPLICATE ARMATURE.

[RECORD, PAGE 541.]

This is a heavy armature used as a substitute for the armature in Exhibit No 34.

DIMENSIONS.

Length of armature	$1\frac{7}{8}$ inches
Width of armature	$\frac{1}{2}$ "
Thickness of armature	$\frac{1}{8}$ "

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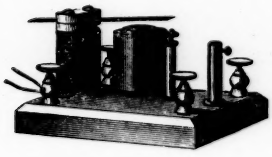
COMPLAINANTS' EXHIBIT No. 48, BELL'S HARMONIC RECEIVER.

(RECORD, PAGE 557.)



DIMENSIONS.

Length of core	$1\frac{1}{4}$ inches.
Diameter of core	$\frac{1}{2}$ "
Diameter of spool	$\frac{1}{8}$ "

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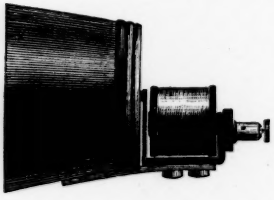
COMPLAINANTS' EXHIBIT NO. 49, D'INFREVILLE MEMBRANE TELEPHONE TRANSMITTER.

(RECORD, PAGE 586.)



DIMENSIONS.

Length of cone	2 inches.
Diameter of cone	$2\frac{7}{8}$ "
Diameter of membrane	$2\frac{1}{4}$ "
Length of spool	$\frac{7}{8}$ "
Diameter of spool	$\frac{7}{8}$ "
Length of armature	1 "
Width of armature	$\frac{3}{16}$ "

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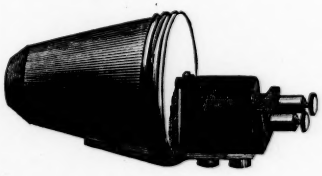
COMPLAINANTS' EXHIBIT NO. 50, D'INFREVILLE MEMBRANE TELEPHONE, RECEIVER.

(RECORD, PAGE 586.)



DIMENSIONS.

Length of cone	$2\frac{1}{4}$	inches.
Diameter of end of cone	$\frac{1}{2}$	"
Diameter of membrane	$2\frac{1}{8}$	"
Length of spool	$\frac{11}{12}$	"
Diameter of spool	$\frac{11}{12}$	"
Length of armature	1	"
Width of armature	$\frac{1}{8}$	"

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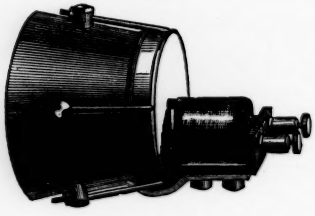
COMPLAINANTS' EXHIBIT NO. 51, D'INFREVILLE BANJO MEMBRANE TELEPHONE, TRANSMITTER.

(RECORD, PAGE 587.)



DIMENSIONS.

Length of cone	2	inches.
Diameter of cone	$2\frac{7}{8}$	"
Diameter of membrane	$2\frac{1}{4}$	"
Length of spool	$\frac{7}{8}$	"
Diameter of spool	$\frac{7}{8}$	"
Length of armature	1	"
Width of armature	$\frac{1}{4}$	"

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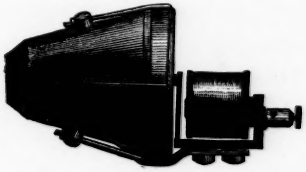
COMPLAINANTS' EXHIBIT NO. 52, D'INFREVILLE BANJO MEMBRANE TELEPHONE, RECEIVER.

(RECORD, PAGE 587.)



DIMENSIONS.

Length of cone	$2\frac{1}{4}$ inches.
Diameter of end of cone	$\frac{1}{2}$ "
Diameter of membrane	$2\frac{1}{8}$ "
Length of spool	$\frac{11}{12}$ "
Diameter of spool	$\frac{11}{12}$ "
Length of armature	1 "
Width of armature	$\frac{1}{4}$ "

COMPLAINANTS' EXHIBIT NO. 53.

[SCHELLEN EXTRACT, RECORD, PAGE 595.]

The rapidity with which successive signals can be transmitted depends essentially upon the time required to charge and discharge the line. This time increases with the length and section of the conductor; moreover, as the discharge always occupies a longer interval than the charge, it follows that the signals will become indistinct at the receiving end if they are sent into the line before the discharge shall have been effected, as in this case the charge and discharge combine and cause a prolongation of the signals, causing them, as it were, to run together.

It will be readily understood from this, that the armature of an electro-magnet or the needle of a galvanometer may be caused to move even before the current in the line has attained its permanent condition, and may in like manner return to a position of rest before the line is completely discharged.

The armature of an ordinary electro-magnet is necessarily at a greater distance from its poles at the moment when it is attracted than at the moment when it is released after having been attracted; consequently, the strength of current which will be required to attract the armature must be much greater than that which will permit it to be released or drawn away by the retracting spring. Therefore, a telegraphic signal which is to be produced by means of the armature of an electro-magnet, cannot be completed until the current has attained the necessary strength to cause it to be attracted, and has again sufficiently diminished to allow it to be drawn away by the tension of the spring. The more nearly the values of these two strengths of current can be made to approximate each other, the more rapidly successive signals may be received. Consequently, when the receiving instrument consists of an electro-magnet, the rapidity of signalling depends essentially upon the distance of the armature from its poles, and upon the amount of play which the latter is permitted to have. The less the distance through which the armature moves, the more rapidly the signals may be made to succeed each other. The degree of sensitiveness of an electro-magnetic instrument has but little influence upon the rapid-

ity with which the signals may be made to succeed each other. For example, let us suppose that the current in the permanent condition of the line is equal to 25, but that the armature of the electro-magnet is attracted as soon as the current has gained a strength of 10, and that it falls off again as soon as, by the disconnection of the battery, the strength of the current has diminished to 7. A distinct signal will be obtained in this case whenever the current increases from 7 to 10 and decreases again to 7. If the apparatus is made less sensitive by increasing the tension of the spring, then the current must be increased in order to overcome this tension and attract the armature. If we suppose that this attraction takes place when the current has attained the strength of 15, and that the armature is released when the current is diminished to 12, the margin will be as great, if not greater, in the latter case, and therefore the less sensitive instrument will operate at least as rapidly as the other.

In the arrangement of the electro-magnet which was invented by Hughes, the action is entirely different. In its normal position of rest, the armature is held nearly in contact with a permanent magnet, the tension of the retracting spring being increased to an extent almost sufficient to overcome the attraction of the latter. When this permanent magnetism is diminished in the smallest degree by the action of the current, the armature instantly falls off, and is afterwards replaced in its original position, not by the action of the current, but by means of a mechanical device, which is set in action by the falling off of the armature. Therefore, the sooner the current attains sufficient strength to release the armature, the quicker the electro-magnet operates.

COMPLAINANTS' EXHIBIT NO. 54. H. B. RENWICK LIGHT ARMATURE MEMBRANE TELEPHONE, TRANSMITTER.

[RECORD, PAGE 628.]

COMPLAINANTS' EXHIBIT NO. 55. H. B. RENWICK LIGHT ARMATURE MEMBRANE TELEPHONE, RECEIVER

[RECORD, PAGE 628.]

COMPLAINANTS' EXHIBIT NO. 56. H. B. RENWICK HEAVY ARMATURE MEMBRANE TELEPHONE, TRANSMITTER.

[RECORD, PAGE 628.]

COMPLAINANTS EXHIBIT NO. 57. H. B. RENWICK HEAVY ARMATURE MEMBRANE TELEPHONE, RECEIVER.

[RECORD, PAGE 628.]

These telephones are described by Mr. Renwick as made in exact conformity with the Bell patent, 174,465, of March 7, 1876.

Exhibit 54 differs from 56, and 55 from 57, only in respect to the size of the armature.

DIMENSIONS OF EXHIBITS 54 AND 56.

Length of cone	4 inches.
Diameter of end of cone	$4\frac{1}{2}$ "
Diameter of membrane	$2\frac{3}{4}$ "
Length of spool	$1\frac{1}{2}$ "
Diameter of spool	$\frac{7}{8}$ "
Length of armature of 54	$1\frac{1}{2}$ "
Width of armature of 54	$\frac{5}{8}$ "
Thickness of armature of 54	$\frac{1}{64}$ "
Length of armature of 56	$1\frac{5}{8}$ "
Width of armature of 56	$\frac{5}{16}$ "
Thickness of armature of 56	$\frac{1}{16}$ "

DIMENSIONS OF EXHIBITS 55 AND 57.

Length of cone	$4\frac{7}{8}$ inches.
Diameter of end of cone	$\frac{1}{4}$ "
Diameter of membrane	$1\frac{1}{2}$ "
Length of spool	$1\frac{3}{8}$ "
Diameter of spool	$\frac{7}{8}$ "
Length of armature of 55	$1\frac{1}{2}$ "
Width of armature of 55	$\frac{5}{8}$ "
Thickness of armature of 55	$\frac{1}{64}$ "
Length of armature of 57	$1\frac{1}{16}$ "
Width of armature of 57	$\frac{5}{16}$ "
Thickness of armature of 57	$\frac{1}{16}$ "

DEFENDANT'S EXHIBITS.

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DEFENDANTS' EXHIBIT "WHEATSTONE & COOKE, PATENT." W. C. W., *Ex'r.*

A. D. 1840. - - - - No. 8345.

ELECTRIC TELEGRAPHS.

WHEATSTONE AND COOK'S SPECIFICATION.

To all to whom these presents shall come :

I, CHARLES WHEATSTONE, of Conduit street, Hanover square, in the County of Middlesex, Esquire, for myself, and for WILLIAM FOTHERGILL COOKE, of Sussex Cottage, Slough, in the County of Berks, Esquire, send greeting :

Whereas, we, the said Charles Wheatstone and William Fothergill Cooke, did, by petition, humbly represent unto Her present most Excellent Majesty Queen Victoria, that after considerable application and expence we had invented " Improvements in giving Signals and sounding alarums at distant places by means of Electric Currents," and Her said Majesty, being willing to give encouragement to all arts and inventions which may be for the public good, was graciously pleased by Her Royal Letters-Patent under the great seal of the United Kingdom of Great Britain and Ireland, bearing date at Westminster, the twenty-first day of January, one thousand eight hundred and forty, in the third year of Her reign, for Herself, Her heirs and successors, to give and grant unto us, the said Charles Wheatstone and William Fothergill Cooke, our executors, administrators and assigns, Her especial license, full power, sole privilege and authority, that we or they, by ourselves or themselves, or by our or their deputies, servants or agents, or such others as we or they should agree with, and no others, during the term of fourteen years from the date of the said Letters-Patent, should and lawfully might make, use, exercise, and vend our said invention within that part of Her said Majesty's Dominions called England, Her Dominion of Wales, and Town of Berwick-upon-Tweed, in such manner as to us, our executors, administrators, and assigns, shall seem meet, and as that we or they shall enjoy the whole profit and advantage aris-

ing by reason of the said invention during the said term of fourteen years, and for that end Her said Majesty requires and strictly commands all Her subjects whatsoever, within England, Wales and Berwick upon-Tweed aforesaid, that they shall not, neither directly or indirectly make, use, or put in practice our said invention, or any part thereof, nor in anywise counterfeit, imitate, or resemble the same, nor make any addition thereto or subtraction therefrom, whereby to pretend himself or themselves to be the inventor or inventors thereof. And whereas the said Letters-Patent contain a proviso obliging us, the said Charles Wheatstene and William Fothergill Cooke, particularly to describe and ascertain the nature of our said invention, and in what manner the same is to be performed, by an instrument in writing under our hands and seals, or under the hand and seal of one of us, and to cause the same to be enrolled in Her Majesty's High Court of Chancery within six calendar months next and immediately after the said in part recited Letters-Patent, as in and by the same (reference being thereunto had) will more fully and at large appear.

NOW KNOW YE, that in compliance with the said proviso, I, the said Charles Wheatstone, for myself and for the said William Fothergill Cooke, do hereby declare that our said invention is described and ascertained in manner following, and by the aid of the four sheets of drawings hereunto annexed, that is to say:

Whereas a former patent was granted to us, the said Charles Wheatstone and William Fothergill Cooke, by His late Majesty King William the Fourth, bearing date at Westminster, the twelfth day of June, one thousand eight hundred and thirty-seven, for improvements in giving signals and sounding alarums in distant places by means of electric currents transmitted through metallic circuits, and whereof the Specification stands enrolled in the Chapel of the Rolls, and in that Specification it was explained, amongst other matters, how the attractive force of occasional or temporary magnetism which may be excited in masses of iron (that are not magnets of themselves), by electric currents conducted in suitable spiral convolutions around such masses, could be applied for giving signals, and for sounding alarums at distant places, our present improvements are for the most part further and improved means of applying the said attractive force of occasional magnetism for such purposes.

I shall first describe certain apparatus or mechanism, which is constructed according to our said improvements, and then at the conclusion of this our Specification, I shall point out the particular improvements whereof the exclusive use is granted to us by the said Letters-Patent.

An apparatus capable of giving signals and sounding alarums is represented in Sheet I. of the Drawings hereunto annexed. One such apparatus is to be situated at one of the distant places, and another like apparatus at the other of the distant places, between which communication, of the nature of telegraphic intelligence, is to be carried on by giving signals and sounding alarums by means of electric currents transmitted through two long metallic wires extending from one of the distant places to the other, and forming a metallic circuit, in the manner fully explained in our said former specification; that is to say: the said two long conducting wires or telegraphic wires forming a continuity of metal, and being kept insulated one from the other (although laid close side by side), if the end of one of the two wires is brought in contact with one pole of a voltaic battery, and the end of the other wire with the contrary pole of the same battery, the two distant ends of both the wires being conjoined with metallic contact, then the two wires will form what is called a metallic circuit, through the whole length of which an electric current will be transmitted in consequence of a continual transmission of electric action, which as soon as such circuit is formed begins to proceed from one pole of the battery along or through all the length of one wire, and then back again through all the length of the other wire, with a very great velocity of transmission, in order to return to the other pole of the same battery, the electric current thereby performing a circuit from the battery and back again thereto; and providing the battery is kept in working order, the said electric current, or transmission of electric action in a circuit, will continue without interruption or cessation so long as the metallic circuit is maintained; that is, so long as the aforesaid contacts of the ends of the two wires with the two poles of the battery (and so long as the continuity of metal throughout the whole length of the two wires and at their distant ends) is continued. And if one of the said long conducting wires is coiled spirally to form a great number of convolutions around a mass of soft iron, although the same is not magnetic, magnetism will be excited in such mass whenever an electric current is transmitted through the said circuit and convolutions, and by such occasional or temporary magnetism another small piece of iron, being suitably disposed, may be atrracted and drawn towards the first-mentioned mass with a sufficient force and motion to give a small action to some suitable mechanism; but if either or both the ends of the two wires are disconnected from the pole or poles of the battery, or if the wires are disconnected one from the other at their distant ends, or, in short, if the continuity

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of metal throughout the circuit is broken at any part thereof, then the electric current will cease to be transmitted, whereupon the said occasional or temporary magnetism will cease also, and consequently the aforesaid small piece of iron which was previously attracted by such magnetism as aforesaid, being no longer attracted, may retreat from the said mass of soft iron by the reaction of some small weight or spring which is suitably applied so as to be always operative on the said small piece of iron, with a slight tendency to draw the same away from the mass of soft iron. But when occasional or temporary magnetism is excited therein, then the attractive force of that magnetism will overcome the said tendency so as to give motion to the small piece of iron in manner above stated; but on the cessation of the magnetism the reacting spring or weight will give a contrary motion to the same piece of iron. And in our said former Specification the action so produced by the attractive force of occasional or temporary magnetism, and the reaction consequent upon the cessation of such magnetism, was described as being applied to the sounding of alarums in distant places. But the chief object of our present improvements is to obtain (by various means now about to be described) a sufficient diversity of signals from successive alternations of such action and reaction for carrying on a telegraphic communication of intelligence by means of such signals between distant places, where duplicates of the apparatus are situated with the two (or in some cases three) long conducting or telegraphic wires extending from one apparatus to the other. The mechanism which we employ for obtaining diversity of signals, is of the nature of clockwork, and in its simplest form may be described as containing parts answering to the escapement wheel of a clock with its axis, and the seconds' hand fixed on that axis for pointing out seconds on the dial plate. Let the said dial plate be divided into twenty-four or thirty, or other suitable number of divisions (instead of sixty, as is usual for seconds), and let each division be numbered or lettered with those characters which are to be used for signals, the escapement wheel having twelve or fifteen teeth, that is half as many teeth as the number of divisions and characters on the dial, also let any suitable kind of pallets of an escapement or driver and clawker be applied to the teeth of the wheel, with the small piece of iron before mentioned connected with the said pallets or driver and clawker in any such manner as that whenever the said piece of iron is moved, in manner already mentioned, by the attractive force of the occasional or temporary magnetism that is excited by the transmission of an electric current through the metallic circuit, which is formed as afore-

said, the said motion of the piece of iron shall then cause the wheel to be turned round a space just equal to one-half tooth, whereby the hand will be moved away from one division and character on the dial plate, and carried forward to point to the next adjacent division and character thereon; also that whenever by cessation of such magnetism consequent on breaking the circuit, the said piece of iron returns or moves in a contrary direction by reaction of its aforesaid weight or spring, such returning motion shall cause the wheel to be turned round a space just equal to another half tooth, whereby the hand will be moved forwards to point to another succeeding divison and character on the dial. This being premised, it may be understood that an apparatus so constructed may be placed at each of the distant places between which telegraphic communication is to be carried on, having two long conducting or telegraphic wires extending from one such apparatus to the other, and one of those wires making like coils or convolutious around the aforesaid masses of soft iron belonging to each apparatus, the two apparatuses being in every respect alike; and when the two wires are conjoined together at their most distant ends, so as to prepare them for forming a metallic circuit, then the near end of one wire being connected with one pole of the voltaic battery, and the like end or the other wire being connected with the other pole of the same battery, an electric current will be transmitted throughout their whole length, and that current will excite occasional magnetism in the masses of soft iron belonging to both the near and the distant apparatus at the same time, and by the action already described of that magnetism the hands of both apparatuses (those hands having been previously adjusted to point to like characters on their respective dials) will be moved simultaneously, one division each on their respective dials, so as both to point to a like character thereon, and then by disconnecting either of the wires from its connection with the battery, or by breaking the circuit in any way, the transmission of the electric current, together with the occasional magnetism which it had excited, ceases in both apparatuses at the same time, whereupon the reaction by weight or sping, already described as being consequent upon such cessation, causes the hands of both apparatuses to move simultaneously one division further on their respective dials, but so as both to point to a like character thereon. Then by again reconnecting the said disconnected wire with the battery, or by otherwise restoring the circuit, another repetition of the same action, as above described, takes place, and both hands are thereby moved forward another division, and then on breaking the circuit both hands are

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again moved another division more, and so on by alternately forming and breaking the metallic circuit in that manner, the two hands may be worked round step by step from one division and character on their respective dials to the next division and character at pleasure; but, nevertheless, the two hands will in all cases point to a like character on their respective dials, therefore a person situated at one of the said apparatuses can, by alternately forming and breaking the said metallic circuit, cause the hands of both apparatuses to move round alike, and by leaving only very short but regular intervals between each act of breaking and forming the circuit, he can cause the said hands to advance forwards with a continual stepping motion without resting long enough at any one character on their respective dials to indicate any deciding pointing thereto. But when he has thus brought the hand of his own near apparatus, and consequently the hand of the other distant apparatus, to point to some one character which he intends to use at the time for giving a signal, then by ceasing to go on making and breaking the circuit both hands will stand still, both pointing alike to the said character for a sufficient time for his correspondent at the place to observe (by the pause that the hand of his apparatus has made opposite to the said character on its dial) that he is to note down that character as a signal given to him, and after a sufficient pause for that purpose then the first-mentioned person may resume the aforesaid operation of alternately making and breaking the circuit, in order to cause the hands of both dials to begin moving forwards again step by step without any decided pause in their motions until the hands are brought opposite to some other character which he intends to use for giving his next signal, and then he again discontinues the alternate making and breaking of the circuit in order to leave both hands standing still opposite to the said character for a sufficient time for his correspondent at the distant place to observe, by the pausing of the hand of his apparatus, that he is to note down the said character as another signal given to him, and after due pause the first-mentioned person may begin again, alternately making and breaking the circuit as before, in order to move both hands forwards to the character which he intends to use for giving his next signal, where he pauses again, and so on he gives signal after signal as his communication requires; and when he has by so doing completed a sentence of telegraphic communication, he brings both the hands to point upwards to a blank division or character, and there he leaves them standing still to denote that no signal is intended to be given notwithstanding that the hands stand still; in fact they then indicate blank or

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nothing; and whenever the hands are left so standing at blank, the near ends of both the telegraphic wires must be disconnected from the two poles of the battery, and the said two ends must be connected one with another by way of preparation of the apparatus, in order that the person at the distant apparatus may be enabled to give signals by it in return if he desires to do so, for his apparatus is in all respects like to the other, and has a battery, wherefore, if he separates his two ends of the two telegraphic wires one from the other, and then connects those two ends with the two opposite poles of his battery, then a metallic circuit will be formed, and an electric current will be transmitted through that circuit, and although excited by the distant battery instead of the near one, the current will produce all the same effects as already described, viz., it will excite magnetism in the masses of soft iron in both apparatuses at the same time, so as to cause the hands of both apparatuses to move forwards one division each, and then if the person at the distant apparatus breaks the said circuit, both hands will be again moved forwards another division, each by reaction, as already explained, wherefore the person situated at the distant apparatus can give signals to the person situated at the near apparatus, by alternately making and breaking the circuit and by pausing in that alternation whenever he has brought both hands to point to the character which he intends to use for giving a signal. In fact, he can do every thing that has been already described as being done by the person situated at the near apparatus, so that the whole apparatus is adapted for communicating telegraphic intelligence in either direction. The construction of the apparatus admits of many modifications in its parts and mechanism; for instance, instead of hand pointing to divisions on the dial, a small circular dial, with the characters marked thereon, may be fixed on the axis so as to turn round therewith, and being situated behind the dial plate of the mechanism, the said revolving dial will be concealed, except one character at a time, which will be exhibited through a suitable aperture cut out through the dial plate, the effect whereof will be the same as that of a hand, as is well known in ordinary clockwork; also the toothed wheel, or escapement wheel, or ratchet wheel, with its pallets or driver and clawker, may be constructed in various ways, well known and commonly used in other mechanism for various purposes, preferring that way which will be most certain to move the wheel without fail one-half tooth by the action resulting from the excitement of the occasional or temporary magnetism, and then one other half tooth by the reaction (of a weight or spring) which attends the cessation of that magnetism.

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And in order to facilitate the said motion that the wheel with its hand or dial is required to perform, it may have a tendency given to it to turn round, by means of wheelwork actuated by a maintaining power of weight or spring, in the manner of ordinary clocks, and the anchor or pallets which apply to the teeth of the escapement wheel, in the usual manner of clocks, will prevent that wheel from turning more than half a tooth at a time, the action of the occasional or temporary magnetism, and the reaction by weight or spring, being operative alternately on the anchor or pallets of the escapement so as to move the same alternately one way, and then the other way, with a like motion to that which takes place in an ordinary clock when its pendulum is removed, leaving the escapement complete, and what is called the crotch for connecting the same with the pendulum; and instead of an escapement or ratchet wheel with teeth projecting around its circumference a wheel having pins projecting laterally from its flat surface or surfaces may be used with suitable pallets to catch and detain those pins, and prevent the wheel from moving more than half the space between two of its pins at a time; and instead of applying pallets in the ordinary form of an anchor, moveable about a centre or axis, they may be applied to a sliding spindle moveable endways, in a direction parallel to the axis of the wheel. And mechanism may be employed to facilitate and expedite the alternate making and breaking of the circuit, whereby, as already mentioned, the said action and reaction is rendered operative to turn round the wheel and its hand or its revolving dial without pauses, until the character intended to be given as a signal is indicated, and then to stop with a decided pause. Amongst a diversity of constructions for the parts of the apparatus which may be used, we have found the apparatuses represented in the Drawings to answer the intended purposes, and I shall now proceed to describe the Drawings by way of illustration.

Sheet I. Figure 1 is a front elevation of the box containing the mechanism of clockwork and masses of soft iron with a dial for exhibiting the characters which are to constitute signals, and also clockwork for sounding alarums. Figure 2 is a vertical section, shewing the interior mechanism sideways. Figure 3 a front section, to shew the interior clockwork in front. Figure 4, a horizontal plan, and Figure 5 detached parts to explain the masses of soft iron in which occasional magnetism is excited. The same letters and figures are used to denote the same parts in all the figures. One such apparatus as that represented by those Figures is situated at each of the distant places between which the telegraphic communication is to be carried on, the appara-

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tuses at each place being exactly alike. A, A, are the plates of the frame united with pillars like the frame of a common clock. B, the spring barrel for a maintaining power, whereby a train of four wheels and four pinions gives motion to an axis *a*, on which is fixed the escapement wheel *b*, and also the revolving dial *d* is fixed on the extreme front end of the axis *a*, so as to turn round therewith. The revolving dial *d* is divided into twenty-four spaces, and lettered as represented in Figure *d*. The front of the wooden box or case in which the whole is enclosed has a fixed dial plate *c*, with an aperture in it, behind which the movable dial *d* is disposed, so that the characters can be seen one at a time through the aperture. The escapement wheel *b* has twelve pins fixed into its rim and projecting out on each side thereof, parallel to its axis *a*. The pallets of the escapement are two small upright prongs projecting downwards from a horizontal sliding spindle *e*, which is situated over the axis *a*, and which spindle can slide freely endways in the direction of its length, to serve as a horizontal slider for carrying the pallets; one of the prongs of those pallets being at one side of the wheel *b* is for catching the ends of the pins on that side, and the other prong being on the opposite side of the wheel is for catching the ends of the pins on that opposite side. The space between the prongs (measured in the direction of the spindle *e*) is much less than the length of the pins, wherefore, when the spindle *e* is pushed endways backwards, its backmost pallet retreats from the backmost end of one of the pins in the wheel, and allows the wheel to turn round until the frontmost pallet intercepts the front end of the next following pin in the wheel *b*, so as to detain the wheel from turning round further than half the space between two of its adjacent pins; and then, if the sliding spindle *e* is drawn forwards endways, its frontmost pallet comes forward out of the way of the front end of that pin which rested against the said pallet, and allows the wheel to turn round until the backmost pallet intercepts the backmost end of the next following pin in the wheel, so as to prevent it from turning more than another half space between two pins. Note, an escapement of a somewhat similar nature has been used in clockwork, and is well known by the French term "echappement a cheville." The pallets and pins of our escapement are not cut sloping, or only very slightly so, because it is not intended that the wheel shall exert any sensible impulse to move the sliding spindle *e* of the pallets endways either way. The small piece of soft iron V, which is to be attracted by occasional or temporary magnetism, as before mentioned, is

fixed fast on the backmost extremity of the sliding spindle *e*, so as to move backwards and forwards with that spindle *e* (see Figures 2 and 4), and two small horizontal pins are fastened into the said piece of iron V, to project out forwards therefrom, and pass through suitable holes in the frame plate, for the purpose of securing the piece of iron V, and also the pallets of the escapement, from turning round about, as the spindle *e* might otherwise permit them to do. That spindle is not intended to operate as an axis, but as a horizontal slider. *m*, Figures 3 and 4, is the reacting spring, whereby the sliding spindle *e*, together with the piece of soft iron V, and the pallets of the escapement, are always drawn forwards. The acting end of the spring *m* presses forwards behind a small stud which stands up from the sliding spindle *e*, out of the boss by which the pallets are fixed to that spindle. The middle part of the spring *m* is fastened loosly to the frame plate by one screw, and the extreme tail end of the spring is drawn towards the plate by a regulating screw *k*, by turning which the reacting force of the spring can be adjusted to suit what is requisite for reaction. U, U, Figure 5, are the masses of soft iron in which occasional or temporary magnetism is to be excited, as before mentioned, whenever it is required. Two such masses, U, U, are disposed side by side to form a pair; they are of cylindrical form, and each one has a disk of brass or copper when fastened upon each of its ends, so that with those disks it forms a bobbin, around which is coiled a great length of fine copper wire closely covered with silk thread for insulation of one coil from another, until the bobbin is completely filled with such coils, and two bobbins thus filled are put together side by side and united at one end of each by a connecting cross piece *w* of soft iron, which is fastened to the end of each piece U by a countersunk screw inserted into the end thereof. At the opposite end of each piece U a piece of soft iron *u* is fastened in like manner by a countersunk screw, but the two pieces *u* have no connection one with the other. The coils of the wire about each of the pieces of soft iron U must go round each piece in the same direction of coiling, and the ends of the wires coiled about each piece U being united together, the whole of the coils around both pieces U will operate like one continuous coiling in the same direction around the two prongs of a horseshoe of soft iron, such as was described in our said former Specification, and which is commonly called a voltaic magnet, for the two pieces U, U, when firmly united together by the connecting cross piece of iron *w*, will act the same as the two prongs of a horseshoe would do, but by being made in two pieces, each having the form of a bobbin, the coiling of the wire can be

better done, and a greater number of coils laid on than could be done around the two prongs of a horseshoe. The mode of making voltaic magnets by coiling of covered wire around pieces of soft iron being well known, no further instructions can be required for making them in the manner shewn in Figure 5. We prefer to use smaller sized wire for the coils than is commonly used for voltaic magnets, because a greater number of convolutions of small wire can be wound around the iron U within the same bulk, and consequent proximity to the iron, than could be done with such large wire as has been usually employed. A voltaic magnet constructed as shewn in Figure 5, and as above described, is placed in the apparatus as shewn at W, W, in Figures 2, 3, and 4, with the two pieces *u*, *u*, or poles of the voltaic magnet situated opposite to the aforesaid piece of soft iron V which is fastened on the end of the horizontal sliding spindle *e*, that also carries the pallets of the escapement, and the ends 21^a, 21^b, of the coiled wire are to be connected with one of the the two long telegraphic wires, so as to form a part of the metallic continuity thereof, in order that whenever an electric current is transmitted along that telegraphic wire, the said current cannot fail to be transmitted along the spiral convolutions which the coiled wire makes around the two masses of soft iron U, U, that transmission taking place in the same direction around each of the two masses U, U, and thereupon they will instantly become magnetic, so that their two poles *u*, *u*, will exert magnetic attraction to draw the piece of soft iron V towards them, and they will continue to do so as long as such transmission along the said spiral convolutions is continued, but the instant that the said transmission ceases, the magnetism and attraction will cease also, all which are the well known properties of a voltaic magnet. The said magnet W, W, is fixed in place in the apparatus by screwing its cross piece *w* of soft iron to a brass or copper support *n* standing up from a flat tablet R, which is applied on the top of the frame plates A, A, of the clockwork in such manner as to be capable of sliding horizontally by action of a regulating screw, whereof the head *r* reaches to the outside of the case, and by turning that head *r*, the distance of the poles *u*, *u*, of the voltaic magnet from the piece of soft iron V can be regulated, and by that means, together with due regulation of the force of the reacting spring *m* by its regulating screw *k*, before described, the apparatus can be regulated to suit the intensity wherewith the occasional or temporary magnetism is excited, in order that the attractive force of that magnetism operating at the two poles or pieces of iron *u*, *u*, may not fail to draw the piece of soft iron V towards them with an instan-

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taneous motion in opposition to the strength of the reacting spring *m*. And also that the said spring *m* may not fail to cause the said piece V to return or retreat from the poles *u*, *u*, with a like instantaneous motion, as soon as ever the occasional magnetism ceases, and every such motion of the piece of iron V, whether produced by attraction or by reaction, being attended with a corresponding motion of the sliding spindle *e*, and of the pallets of the escapement, they will allow the escapement wheel *b*, and the revolving dial *d*, to turn round one-half space of the pins in the wheel and one division of the dial every time. And note, the operator may sometimes require to actuate the escapement so as to allow the wheel *b* and moveable dial *d* to turn round without any excitement of occasional magnetism. For this purpose a small sliding pin is fitted to slide endways through a hole in the front of the case, and has a knob P on the front end of it, to be touched when required by the finger. A spring *p* is fixed within the case to press against the end of the sliding pin, with a tendency to push the knob P outwards. The lower end of the spring *p* stands opposite to the end of the sliding spindle *e*, but without touching that end, unless the knob P and sliding pin is pushed inwards, for then it bends back the spring *p* so as to carry back the end thereof against the front end of the sliding spindle *e* in order to move the same endways, in like manner as occasional magnetism would do, and then on releasing the button P the sliding rod *e* returns by reaction of its spring *m*, wherefore by alternately pressing and releasing the button P the moving dial *d* can be caused to turn round at pleasure, which is sometimes requisite (in like manner as setting the hands of a clock to time) in order to set the apparatus right at first starting, so that it may exhibit the same character as its corresponding apparatus at the distant place. For whenever the two apparatuses at the near and at the distant place are left standing still in the intervals between making telegraphic communications by them, the dials *d* of both should always exhibit the blank character indicating that nothing is communicated; or a cross –|– may be marked on that part of the dial *d* to indicate the blank, and whenever either apparatus does not indicate –|– or blank whilst it is so standing still in the interval between the making of communications, then the person in charge of that apparatus will know that something is wrong, and he must use the button P to set the dial of his apparatus to shew –|– or blank, and if both apparatuses are set in that manner they will be properly prepared for use, for they will begin aright by exhibiting like characters on their respective dials, and then, pro-

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vided that every part is in good order when they are put in operation by means of alternate excitement of temporary magnetism and cessation thereof, as hereinbefore explained, the mechanism of each apparatus will be operated upon simultaneously and precisely in the same manner the one as the other, so that the dials *d* of both will be moved round alike, and they will at all times exhibit like characters whether they are moving on step by step or pausing or standing still. It is an indispensable condition for the successful communication of telegraphic intelligence that both should exhibit like characters, and whenever from default of attractive force from the magnetism, or of reacting force by the spring *m*, or of maintaining power B in the clockwork, or from partial derangement of any part, either apparatus fails to move its dial contemporaneously with that of the other apparatus, so as by missing one or more times to get behind the other in the characters which it is exhibiting, then there will be a confusion in the telegraphic communication; but nevertheless, the fault will be detected so soon as the person who is giving signals comes to the close of a sentence or series of signals, and brings the dial of his apparatus to exhibit –|– or blank, and there leaves it standing still during a sufficient time to denote, as previously agreed, that he has come to such close, because the other dial, although it also stands still, will not indicate –|– or blank; and if after standing still the sufficient time that is observed to be the case, then the faulty dial must be set right by applying a finger to the button P, first pressing and then removing it, until the dial is brought round to exhibit its cross or blank. And as to the mechanism which may be employed, as hereinbefore mentioned, to facilitate and expediate the alternate mak ing and breaking of the metallic circuit which is to be formed for the transmission of an electric current through the two long conducting or telegraphic wires from pole to pole of the voltaic battery belonging to one of the apparatuses, and which said current will be also transmitted through all the coils around the voltaic magnets W, W, of both apparatuses, and by which alternate making and breaking it is that the occasional or temporary magnetism of the voltaic magnets W, W, becomes alternately excited and discontinued, so that by the attractive action thereof, and then, by the reaction consequent upon its cessation, the clockwork is actuated, as above described, in both apparatuses alike, in order to turn round the dials of both apparatuses simultaneously and similarly, so as to exhibit like characters by both dials, the said mechanism for making and breaking the circuit may be constructed in various ways, but what we prefer is, to use a moveable circle, having divisions

answerable to and marked with like characters to those on the dials *d* of the two apparatuses, the action of the said mechanism being such that the operator, by merely turning round that moveable circle by his hand or finger, will cause the alternate making and breaking of the circuit to take place, as is requisite for actuating the clockwork so as to turn the dials round step by step in the manner already explained. And the required alternation of making and breaking will be duly performed by the mechanism now about to be described, without other trouble to the operator than that of turning the said moveable circle steadily round about with a tolerably slow motion; and as he does so the dial *d* of both the apparatuses are caused, by the alternate making and breaking of the circuit, to turn about with a corresponding motion one to the other, and also to the motion that is given by the operator to the moveable circle by his hand; for as the several characters thereof pass in succession opposite to a fixed index, the dials *d* of both apparatuses will exhibit the same character as that character on the moveable circle which is for the moment opposite to or passing by that index; and when the operator ceases for a while to turn the moveable circle, and leaves it standing still with any one of its characters opposite to the said index, then the dials of both apparatuses will stand still also, and will both exhibit that said character. It will be known by the pause that the dials make in their previous motion that the character which they exhibit whilst they do so pause is to be noted down by the person at the distant apparatus, as a signal given to him, but he takes no notice of any of the characters which his dial exhibits transiently and in a rapid succession as it moves slowly round, but it is when it makes a pause that he must observe and note down the character which it then exhibits, as a signal given to him; and, in like manner, the person at the near approaches, who gives the signals whilst he is turning the moveable circle round for that purpose, takes no notice of those characters on the moveable circle which pass in rapid succession by the index thereof as he turns it round, but he confines his attention for the time to that particular character on the said moveable circle which he then intends to use for giving a signal, and he turns the moveable circle steadily but slowly round until he brings that particular character opposite to the index, and there leaves it standing during a sufficient pause to denote that the said character is given by him, and is to be received by his correspondent as a signal. And from the office which is to be performed by the said moveable circle and its mechanism, we call the same a communicator. A communicator, suitable to used along with the apparatus

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represented in Sheet 1 (and already partly described), is also represented in that Sheet, Figure 6 being a horizontal plan, and Figure 7 a side elevation. I is a round wooden board, serving as the base of the communicator, the revolving circle of which is mounted on the upper end of an upright pillar or axis J, standing up from the centre of the base I. K is the revolving circle, which is fitted by its centre on the upper end of the axis J, so as to turn round thereon with an easy motion, but with a gentle friction, in order that it may retain any position that may be given to it. The upper surface of the revolving circle K is divided the same as the revolving dial, Figure *d*, into twenty-four divisions, and each division is marked with one of the characters as shewn in Figure 6, so as to correspond exactly to the dial, Figure *d*; and opposite to every character a metal pin *q* is fixed into the rim of the circle K, so as to radiate out therefrom, and the pins *q* form twenty-four handles or figures pins for turning the circle round; by applying the end of a finger to the interval between two of these pins *q*, and moving that finger round in a circular orbit, it thereby carries the circle K round with it. L is a pillar standing up from the base I, just beyond the circle described by the ends of the finger pins *q*, for the purpose of supporting two wire pins *s*, *s*, which are fastened one above the other into the upper end of the pillar L, and project out horizontally therefrom in a direction towards the centre of the circle K, one fixed pin *s* being above and the other below the moveable finger pins *q*, which as they are carried round in circular motion pass in succession between the two fixed pins *s*, *s*, but without touching them. The use of those fixed pins *s*, *s*, is to serve as the fixed index to the divisions and characters around the revolving circle K, and also to arrest the progress of the finger when it is moved round in a circular orbit as above mentioned, for, when that finger comes in contact with the said pins *s*, *s*, and is stopped thereby, the circle K will stand with that one of its twenty-four characters at the index pins *s*, *s*, which has been previously selected by the finger (when it was applied to the finger pins *q*) as the character that the finger was to bring round to the index *s*. It may be considered that the revolving circle K on the communicator, with its divisions and characters, is the counterpart of the revolving dials *d* of the clockwork apparatuses, and that the fixed index pins *s*, in designating which of those characters is exhibited, correspond to the apertures in the fixed dial plates *c*, Figure 1 and 2, through which the characters of the moving dials *d* are exhibited, and with that understanding the arrangements for alternately making and breaking the metallic current of the

telegraphic wires may be explained as follows :—The edge or circumference of the revolving circle K, beneath the part from which the finger pins q project out, is divided into twenty-four, and at every other division the edge is cut out to form twelve notches, being half as many as the number of divisions and finger pins q in the circle K. Those notches are disposed at equal distances apart, and are filled up with pieces of wood, which complete the circular form of the edge of the rim; but that circular edge is composed of a succession of wood and metal surface alternately. A blade spring z, which is fastened to the base I, and stands up therefrom, applies its upper end to the said circular edge of the revolving circle K, so as to press against the same, and by the elasticity of the spring z its said end is certain to preserve an effective contact with that edge as the same turns round, but in so doing the contact of the spring z will be alternately on the wood and on the metal, and when it is on the metal the metallic circuit will be established or made, but when on the wood that circuit will be broken. The spring z is always kept in metallic communication with one of the poles of the voltaic battery belonging to the apparatus by means of a wire, part of which is concealed in a groove cut out in the under side of the wood base I, but which wire passes, as shewn by dotted lines, from the lower end or root of the spring z to a screw button z^1 at the edge of the base I, and that screw button serves to connect with a wire z^2, which extends from one pole of the battery, suppose, for instance, the zinc pole. Then the other or copper pole of the same battery is always connected with the end of one of the two long conducting or telegraphic wires, which extend to the distant apparatus, suppose, for instance, with that one of the two which will in future be called 21. Another similar blade spring 22^c stands up from the base I, and its upper end applies in continual metallic contact with an interior rim beneath the revolving circle K. The metal of that circle is kept, by means of the spring 22^c, in continual metallic communication with the end of the other one of the two long conducting or telegraphic wires, which extends to the distant apparatus, and which will in future be called 22, for the lower or root end of the spring 22^c connects by a wire concealed in a groove beneath the base I, as shewn by dotted lines, with the screw button 22^1, and to that end of the telegraphic wire 22 is connected. There is also a third spring 21^c which stands up from the base I, and its upper end applies in continual contact with the edge of a circular wooden rim h, which is fastened to the under side of the circle K, and revolves therewith. The lower or root end of

the spring 21^c connects by a wire concealed in a groove beneath the base I, as shewn by dotted lines, with a screw button 21^d, which is connected with the line of the long telegraph wire 21, near to that end thereof which is connected, as before mentioned, with the copper pole of the battery, so that the spring 21^c becomes a short off branch from that end of the line of the wire 21. And note, for convenience of connection there is another screw button *c* 1, which connects by a wire with the copper pole of the battery, and that button always communicates by a wire concealed in a groove beneath the base I with the next screw button 21^d, to which the end of the long telegraphic wire 21 is connected, wherefore the two screw buttons, 21^d and *c* 1, may be considered as points upon the line of the long telegraphic wire 21, near to that end thereof which is always in connection with the copper pole of the battery, and it is at one of those points (for instance, 21^d) that the connection with the spring 21^c branches off. The said branch and spring 21^c produce no effect whatever, so long as the end of that spring is merely in contact with the edge of its wooden circle *h*; but there is a piece of metal inlaid into the circumference thereof at one place, to which place the spring 21^c applies whenever the revolving circle K is turned round, so that the blank character (or –|–) on the revolving circle K stands opposite to the fixed index pins *s*, and that said piece of metal in the wooden circle *h* being always in metallic connection with the metal of the circle K, the said contact of the spring 21^c with that piece of metal causes the end of the telegraphic wire 21 to become connected with the end of the other long telegraphic wire 22, because, as already stated, the metal of the circle K is kept in continual connection with that wire 22 by the continual metallic contact of the spring 22^c, wherefore whenever the revolving circle K of the communicator is turned round so as to bring its blank character (or –|–) opposite to its fixed index pins *s*, then the ends of the two long telegraphic wires 21 and 22 will be connected together, and then those two wires may be considered as conjoined into one very long wire, coming by the long course 21 from the distant apparatus to the near apparatus, and there making a bend and then going back again, by the long course 22, to the distant apparatus. And at the same time the upper end of the spring *z* applies to one of the pieces of wood in the edge of the under rim of the revolving circle K, so as to break off all connection between the metal of that circle K and the zinc pole of the battery, and consequently all connection between that said pole and the telegraphic wire 22. Hence

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whenever the apparatus is left at rest in the interval between successive telegraphic communications it will have the aforesaid connections of its parts, and the position of the revolving circle K will be at its blank character (or –|–), and that is the position from which every fresh sentence of telegraphic communication that is to be made by the apparatus must set out as its commencement, and likewise, as already stated, the moving dials *d* of both the near and the distant clockwork apparatuses must then exhibit their blank character (or –|–), and if either of them does not do so, it must be set right by aid of the knob P, in manner already described.

Figures 1 and *d*, 6 and 7, Sheet I., represent the parts in the said starting position. These circumstances being understood, the mode of giving signals by the apparatus is as follows:—Suppose the word DAY is to be communicated, the character which is to be given as as a first signal is to be selected upon the revolving circle K, whilst the same is standing still, and the finger is then to be inserted into the space behind that finger pin *q* which radiates out from the said character (in this instance the letter D is to be selected), then by moving the finger deliberately round in a circular orbit in the direction of the arrow, Figure 7, the revolving circle K will be carried round, and as it moves the revolving dials *d* of both the clockwork apparatuses will move round step by step coincidently with the motion of the circle K, until the finger gets round to the fixed pins *s*, and there they will stop its further motion with the character intended to be given for a signal (letter D in the present instance) opposite to those pins *s*, and at the same instant both dials *d* will stop also when they are both exhibiting a like character (letter D), and by the pause his dial then makes, the person at the distant apparatus will know that he is to note down that character (letter D) as the first signal given to him. The finger being withdrawn from the finger pins *q* is then removed to insert it afresh behind the finger pin *q* which radiates out from that character which is to be used for giving a second signal (in this instance letter A), and by the time that a sufficient pause has been made for noting down the former signal, then the revolving circle K is again moved deliberately round by the finger until the further motion of the finger is stopped by the fixed pins *s*, and the circle K will also stop with the character in question (letter A) opposite to the pins *s*, and the revolving dials *d* will both have moved round with a corresponding motion to that of the circle K, and will stop when it stops, and will then exhibit a like

character to that at which the circle K has stopped (viz., letter A), which the person at the distant apparatus will note down; and then in like manner the third signal (letter Y) will be given, after which, if the intended communication is completed for the present, that fact is to be expressed by turning the revolving circle K until it stops at its blank character (or –|–); both dials will do the same, and then all the parts will be at their starting position, as they were at the commencement; or if the communication is not finished, but only a word of an intended sentence is completed, then the character (–) is to be used as a signal denoting the completion of a word, and that may be followed by commencing the next intended word. And note, it will be evident that the extent to which the revolving circle K will require to be turned round for making each signal will vary very much; for example, in the instance above mentioned of the word DAY, the first letter, D, required the circle K to be moved four divisions, then the second letter, A, required a motion of twenty-one divisions, and the third letter, Y, twenty divisions, after which it required a motion of three divisions more to bring the parts to their starting position, viz., the blank character (or –|–), or if it was the (–) instead of the blank, a motion of only two divisions, instead of three, would have been requisite. To explain the operation of making and breaking the circuit in detail, it must be recollected that at the starting or resting position, when the revolving circle K and the dials *d* were all standing at their blank character (or –|–), as appears in the Drawing, that the spring *z* was then in contact with a piece of wood on the lower rim of the revolving circle K, and therefore the metallic circuit was broken, because the zinc pole of the battery was thereby disconnected from the long telegraphic wire 22 to which that zinc pole belongs; and although the other or copper pole of the battery remained connected with the end of the other telegraphic wire 21, that one connection alone would not produce any of the effect of a circuit; and furthermore, the end of the two telegraphic wires 21 and 22 were connected together by the off branch from the end of the wire 21, at 21 *d*, to the spring 21 *c*, because that spring was then in contact with the piece of metal of the wooden circle *h*, which piece of metal is part of the metal of the revolving circle K, and that metal is always in connection by means of the spring 22 *c* with the wire 22, so that it may be considered as the end thereof; therefore, at the said starting or resting position, no circuit being formed, there is no taansmission of an electric cur-

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rent through the long telegraphic wires, nor is any magnetism excited in the voltaic magnets of either of the clockwork mechanisms, consequently the pieces of soft iron *v* in each clockwork will be withdrawn from the pieces of iron *u*, *u*, at the poles of the magnet, by the reaction of the spring *m*. These circumstances being understood, it is easy to trace what change takes place when the revolving circle K first begins to move round the piece of metal which is in contact with the spring 21*c*, passes away therefrom, leaving that spring in contact with the wood of the circle *h*, and thereby the previous connection between the near ends of the two telegraphic wires 21, 22 (that was effected by means of the spring and off branch 21*c*) is broken, and the ends of the two telegraphic wires become disconnected one from the other, but still leaving the copper pole of the battery in undivided connection with the end of telegraphic wire 21 ; and as there is only one piece of metal in the wooden circle *h*, the ends of the two telegraphic wires will continue disconnected all the time the revolving circle K goes round until it regains its resting position. Also by the same first motion of the revolving circle K, the piece of wood in the lower rim *h* thereof, with which the upper end of the spring *z* was in contact, passes away from that spring, and a metal part of the said rim *h* come round into contact therewith ; by that contact with the metal of the revolving circle K, the zinc pole of the battery becomes connected with the end of the long telegraphic wire 22 (whereof, as before mentioned, the revolving circle K may be considered as one end), the copper pole of the battery being in connection, as already mentioned, with the end of the telegraphic wire 21 ; also the distant ends of the two telegraphic wires 21 and 22, being connected one with the other, in consequence of the communicator at that distant end being at its resting position, and effecting the connection of those ends in the same manner as already described, wherefore, under those circumstances, the metallic circuit is formed, and an electric current will be transmitted through all the length of both the long telegraphic wires 21 and 22, and consequently through all the convolutions or spiral coils W, W, which either of those wires makes around the masses of soft iron U, U, or voltaic magnets in the clockwork apparatus, as well at the distant as at the near end of the long telegraphic wires, and instantaneously on the commencement of such transmission through the said coils, the occasional or temporary magnetism of the masses U, U, is excited, so that the pieces of iron *u*, *u*, at their poles attract the pieces of soft iron V towards them, overcoming the reacting spring *m*, and causing the escapement to let the wheel *b* move round

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half a pin, and the dial *d* one division, so as to exhibit the next adjacent character to the blank character (or –|–), viz., the letter A, which is the same character that the revolving circle K then presents to its index pins *s*. Then, as the revolving circle K moves onwards, the metal in its rim *h* passes away from contact with the spring *z*, and a piece of wood in that rim comes to that spring, whereby the connection that it made a moment before with the zinc pole of the battery is disconnected, and the circuit is broken, and then the transmission of the electric current ceases, together with the occasional magnetism which that transmission had occasioned; consequently the poles *u*, *u*, of the voltaic magnet cease to attract the piece of soft iron V, and then the force of the reacting spring *m* draws the said piece V away from those poles *u*, *u*, and causes the escapement to let the wheel *b* move round another half pin, and the dial *d* another division, so as to exhibit the next adjacent character to the former, which being the letter A, this will now be the letter B, and the revolving circle K also presents its letter B to its index pins *s*. Then as the revolving circle K moves onwards the piece of wood in its rim *h* passes away from its contact with the spring *z*, and the metal part of that rim comes into contact, thereby making the circuit again, and instantly it transmits an electric current, which produces a renewal of all the effects above described, including a further advance of the dials *d*, and the exhibition of their next character (viz., letter C); and as the revolving circle K continues to move onward always in the same direction, the metal of its rim *h* passes away from its contact with the spring *z*, and is succeeded by a piece of wood, and the circuit is broken again as before, and that causes the dial to exhibit their next character (viz., letter D). In that manner the circuit is alternately made and broken by action of the revolving circle K, with the certainty of being decidedly made and decidedly broken at every alternation; and if all the parts are kept in good working order there will be no failure of action in the dials *d* to exhibit a different succeeding character for every succeeding alternation, although alternations may be made to succeed each other with extreme rapidity by turning the revolving circle K briskly round; and in order to avoid loss of time it will be desirable to turn it as quickly as it is found by experience that the action of the alternate making and breaking of the circuit, and the consequent operation of the voltaic magnets on the escapement and clockwork, can be performed without risk of failure to turn the dials correctly, but how quickly that may be will depend upon the perfection of the action of the clockwork apparatus and voltaic magnets, the conducting power and

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insulation of the long conducting or telegraphic wires, and the perfect contact of all the parts which are to form continuity of metal for the circuit. And although one of the apparatuses at one end or terminus of the line of the long telegraphic wires has been hereinbefore called the near apparatus, and the apparatus at the other end or terminus of that line the distant apparatus, nevertheless that distinction was only used to facilitate the explanation and the description of the Drawing, Sheet I., which represents only one apparatus, and that one was considered as the near apparatus; but in reality no such distinction can be fairly established between the two apparatuses, because they are both precisely alike, and either one can be used to communicate signals to a person situated at the other apparatus; all that is requisite to be observed is, that whenever the two apparatuses are left standing still in the interval between telegraphic communications, that the revolving circles K of their several communicators shall be left standing at their blank character (or –|–), in which case all the ends, that is, each of the ends of the two long telegraphic wires, will be connected together by the contact of each of the springs 21*c* with the piece of metal in the wooden circle *h* of the communicator of each apparatus, as already fully described, whereby the ends of both the telegraphic wires will stand thus connected at each terminal apparatus, and then in that state the whole apparatus is ready for operating to communicate the telegraphic intelligence in either direction between the two terminal apparatuses. For if the revolving circle K of either one of the communicators is turned round it will operate in every respect in the manner already explained to give signals at the other apparatus. That apparatus at which signals are to be received being invariably kept with its communicator standing at its blank (or –|–) in order that it may keep up the requisite connection between the ends of the two telegraphic wires at that apparatus; and although it has been hitherto described as if there were only two of the apparatus such as represented in Sheet I., one being situated at each of the distant places between which telegraphic communications are to be carried on by aid of two long conducting or telegraphic wires extending from one of those places to the other, nevertheless it is to be understood that any number of such apparatuses may be disposed on the line of the said telegraphic wires at intermediate places between the two termini or extreme ends thereof, and the coils of wire around the voltaic magnets in each such intermediate apparatus being connected with one of the two long telegraphic wires, so that the said coils constitute a part of the length or extension of the metallic

continuity of that wire, and so that the electric current which is to be transmitted through such telegraphic wire cannot fail to be transmitted through all the length of those coils around the voltaic magnets, then it is evident that the voltaic magnets and the clockwork mechanism of every such intermediate apparatus will be caused to operate in every respect in the same manner as the two distinct apparatuses hereinbefore described do at the same time operate, and therefore so as to exhibit like signals by their dials. Hence whatever signal is given from the person at the near apparatus at one end of the long telegraphic wires to his correspondent at the distant apparatus at the other end of the same wires (or vice versa, in a contrary direction), the same signal will also be given at every intermediate apparatus, and may be observed by persons stationed at them, who will become spectators or all telegraphic communications that are going on in either direction between the two termini, and whenever such signals are intended to be given, especially to persons so stationed at any of the intermediate apparatuses, the series of such especial signals must be prefaced by some preconcerted signal to signify that intention, and also to signify from which of the two terminal apparatuses the said signals are given. This supposes that the said intermediate apparatuses are not provided with any communicators or voltaic batteries, whereby persons stationed at them can be enabled to operate upon other apparatuses at a distance, so as to give signals from the intermediate apparatus, as well as receive signals thereby; but a voltaic battery and a communicator, such as Figures 6 and 7, may be applied to any intermediate apparatus. And in case one of the long conducting wires (for instance the wire 21) is brought to the communicator of the intermediate apparatus, and its metallic continuity may be there disconnected when required, so as to divide its total extension into two portions, one portion extending from the intermediate apparatus to the apparatus at one terminus, and the other portion extending from the intermediate apparatus to the apparatus at the other terminus. The ends of the disconnected wires 21 are connected with the screw buttons 21^d, 22^d, by which connection their metallic continuity is again restored, for, as has been already explained, when the communicator is standing at its starting position the screw button 21^d is connected by means of its off-branch wire 21*c* with the blade spring 21*c*, which is then in contact with the piece of metal in the wood rim *h* of the revolving circle K, with the metal of which circle the blade spring 22*c* is in constant contact, and that blade spring 22*c* is united by its branch-off wire with the screw button 22*d*, to which the other dis-

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connected end of the long conducting wire 21 has already been united. The communicator of the intermediate apparatus is thus placed in exactly the same position with respect to its own apparatus and the two apparatuses at the two termina for giving and receiving signals as the two terminal apparatuses were with each other.

The Diagram, Figure 9, Sheet II., with the writing thereon, is for the purpose of explaining the general course of the long telegraphic wires 21 and 22, and their connections with the voltaic magnets W, W, of the two terminal apparatuses, together with the requisite branches, which have been already described, for connecting the communicator K and voltaic battery of each apparatus with the ends of the telegraphic wires 21 and 22. If the Diagram, Figure 9, is considered without the dotted lines, it will represent proper arrangements for a simple system of two terminal apparatuses with their telegraphic wires, without any sort of intermediate apparatus, all the arrangements of which simple system have been already fully described in detail. But if the parts drawn in dotted lines are also included, then the same Diagram, Figure 9, will represent the entire system of two terminal apparatuses, with a complete intermediate apparatus provided with its voltaic battery and its communicator, so as to be capable of giving signals as well as its clockwork mechanism for receiving signals.

Figures 20 and 21, Sheet II., represent another form of the apparatus for the attainment of the same objects as the apparatus represented in Figures I., II., III., IV., Sheet I., viz., for the giving of signals by means of the alternate attractive force of a temporary magnet and the reaction of a spring, but in the present apparatus there is no maintaining power for the purpose of revolving the hand or dial for the indication of signals, but the movement of the dial or hand is caused solely by the alternation of the attractive force of temporary magnetism and the reaction of a spring, which is caused to produce effects similar to those produced by the apparatus already described in Figures I., II., III., IV., Sheet I. I shall employ the same letters as are used in those Figures to indicate similar parts in the present apparatus. A is a plate supporting the various portions of the mechanism. *a* is the axis steadied by a light spring; on this axis is fixed the escapement little *b*, and also a light revolving dial or hand *d*; that dial may be divided and lettered as before described, and the escapement wheel *b* must have a corresponding number of teeth. The pallets or clawker and driver are two very delicate springs terminating in claws projecting from the sliding spindle *e*, with a piece of soft iron V, projecting in the other

direction, towards the magnet W; one claw of the pallet presses gently on one side of the wheel *b*, for the purpose of catching the tooth in that wheel, where the piece of soft iron V is attracted by the magnet, and draws it by its forward motion the space of one half tooth in the direction of the arrow. The other prong on the other side of the wheel *b* is adapted for driving with its claw another tooth in the wheel *b* for another half tooth, as soon as the temporary magnetism has ceased to attract the piece V, whereupon the spindle is pushed back by the small spring *m*. It is obvious that when, by employing the communicator and its accessories, Fig. 6, 7, Sheet I., an electric current shall be made to pass by the wires 21*a*, 21*b*, thro' the coils around the magnet W, the same will become magnetized and will attract the piece of soft iron V, and the wheel *b* will be advanced half a tooth, as already explained, whereby the hand on the dial on the axis of the wheel *b*, will be made to advance, but on a cessation of the current by a further movement of the communicator, the spindle will be forced back by the spring *m*, as the magnet will no longer attract the piece of soft iron V, and a further advance of the hand or dial will be the result; and in both instances a signal corresponding with that indicated by the communicator will be exhibited, all which is so closely corresponding with the action of the apparatus already so fully described as to need no further explanation. And whereas our afresaid improvements have been hereinbefore described as if the motion of the dial or hand, Fig. *d*, Sheet I., always depended upon the attractive power of temporary magnetism, and the reaction of a spring *m*, but a magnetic needle placed within a multiplying coil may be made to effect the same object. Figs. 22 and 23, Sheet II., represent such a magnetic needle in its coil or multiplier. Fig. 22 being a front view and Fig. 23 a plan. If the ends of the wire 21*a*, 21*b*, which form their coils around the magnetic needle W are made to form part of an electric circuit, and if an electric current be transmitted thro' those coils, the magnetic needle will be deflected into the position represented in the Drawing, and the pallet *g* fixed upon the axis *a* of the magnetic needle will force the escapement wheel *b* half a tooth in the direction of the arrow; then if the electric current were to be transmitted in a contrary direction thro' the said coils, the deflection of the needle would be reversed, and the opposite arm of the pallet *g* would push the escapement wheel *b* forward through the space of another half tooth, and so on, and the hand or dial *d*, Fig. 23, on the axis *a* would indicate a fresh signal with each such motion, and at each

connected end of the long conducting wire 21 has already been united. The communicator of the intermediate apparatus is thus placed in exactly the same position with respect to its own apparatus and the two apparatuses at the two termina for giving and receiving signals as the two terminal apparatuses were with each other.

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direction, towards the magnet W; one claw of the pallet presses gently on one side of the wheel *b*, for the purpose of catching the tooth in that wheel, where the piece of soft iron V is attracted by the magnet, and draws it by its forward motion the space of one half tooth in the direction of the arrow. The other prong on the other side of the wheel *b* is adapted for driving with its claw another tooth in the wheel *b* for another half tooth, as soon as the temporary magnetism has ceased to attract the piece V, whereupon the spindle is pushed back by the small spring *m*. It is obvious that when, by employing the communicator and its accessories, Fig. 6, 7, Sheet I., an electric current shall be made to pass by the wires 21*a*, 21*b*, thro' the coils around the magnet W, the same will become magnetized and will attract the piece of soft iron V; and the wheel *b* will be advanced half a tooth, as already explained, whereby the hand on the dial on the axis of the wheel *b*, will be made to advance, but on a cessation of the current by a further movement of the communicator, the spindle will be forced back by the spring *m*, as the magnet will no longer attract the piece of soft iron V, and a further advance of the hand or dial will be the result; and in both instances a signal corresponding with that indicated by the communicator will be exhibited, all which is so closely corresponding with the action of the apparatus already so fully described as to need no further explanation. And whereas our afresaid improvements have been hereinbefore described as if the motion of the dial or hand, Fig. *d*, Sheet I., always depended upon the attractive power of temporary magnetism, and the reaction of a spring *m*, but a magnetic needle placed within a multiplying coil may be made to effect the same object. Figs. 22 and 23, Sheet II., represent such a magnetic needle in its coil or multiplier. Fig. 22 being a front view and Fig. 23 a plan. If the ends of the wire 21*a*, 21*b*, which form their coils around the magnetic needle W are made to form part of an electric circuit, and if an electric current be transmitted thro' those coils, the magnetic needle will be deflected into the position represented in the Drawing, and the pallet *g* fixed upon the axis *a* of the magnetic needle will force the escapement wheel *b* half a tooth in the direction of the arrow; then if the electric current were to be transmitted in a contrary direction thro' the said coils, the deflection of the needle would be reversed, and the opposite arm of the pallet *g* would push the escapement wheel *b* forward through the space of another half tooth, and so on, and the hand or dial *d*, Fig. 23, on the axis *a* would indicate a fresh signal with each such motion, and at each

successive change of the deflection of the magnetic needle caused by the course of the electric current through the coil W being reversed, a fresh indication would be given by the dial or hand in like manner, as herein-before already explained.

And respecting the sounding of alarums by the apparatus represented in Sheet I., and herein-before described, the same means are to be used for that purpose as were described in our said former Specification in reference to Figure R, Sheet II. of the Drawings thereto annexed, and as were claimed at the conclusion of that Specification as the seventh particular of the improvements secured to us by our former Letters Patent of the Twelfth of June, One thousand eight hundred and thirty-seven. But in applying that mode of sounding alarums in conjunction with our present improvements now describing, the same voltaic magnet W, W, Figures 2, 3, 4, and 5, that we have already described, and its manner of action for giving signals, is also rendered available for sounding alarums. For this purpose the tablet R, which sustains the magnet W, W, as before described, is in fact a dovetailed groove, into which a dovetailed slider N is fitted, so as to move horizontally across the direction of the length of the voltaic magnet W, W, and that magnet is fixed to and supported by the slider N, so as to be moved thereby, the supporting cock *n* for the magnet being screwed to the slider N, and a stem extends horizontally from that slider through the wood case to the outside, having a head O on the end by which it can be moved from the outside, when the head O is pulled out as far as it will come out, the slider N is thereby moved so as to place the voltaic magnet W, W, in the position shewn in the Drawings, and hereinbefore described, with the poles *u*, *u*, of the magnet W, W, opposite to the piece of soft iron V of the escapement. But when the head O is pushed in as far as it will go, then the slider N with the magnet W, W, will be removed away from the said piece of soft iron V, and will by the same motion be brought opposite to another like piece of soft iron X, which belongs to the alarum, and which piece X is fastened on the extreme end of a horizontal sliding spindle *x*, whereon one detent or pallet is also fastened, and whenever the piece X is not attracted by magnetism, that pallet intercepts a pin in the fly wheel *y* of the alarum wheelwork in order to detain that fly wheel from moving, and, consequently, to prevent the alarum from sounding. The sliding spindle *x* is provided with a reacting spring *l*, having a regulating screw, the same as the regulating screw *k* for the reacting screw *m*, to the slider *e* of the escapement already described. The wheelwork for sounding the alarum is actuated by a main

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spring S, which, by a cog wheel and pinion, turns the serrated tooth wheel *v*, which, by acting on suitable pallets, moves the hammer of the alarum backwards and forwards so as to strike the bell H and sound the alarum. On the axis of the serrated wheel *v* is a cog wheel, which, by a pinion, turns the fly wheel *y* round whenever the piece of soft iron X is attracted by the excitement of occasional or temporary magnetism in the voltaic magnet W, W, when it will draw the spindle *x* endways, so that the detent thereof will release the pin in the fly wheel *y*, and allow the alarum to sound, and it will continue to do so until the cessation of the said magnetism, when the reacting spring *l* will move the sliding spindle *x* endways, so that its pallet will again intercept the pin in the fly wheel and stop the alarum. Every apparatus, whether terminal or intermediate, being provided with such an alarum, it is to be kept prepared for sounding by always pushing in the head O as far as it will go, and winding up the springs S and B, if requisite, whenever telegraphic communications have been concluded for the present, and all the several apparatuses being left in that state will be ready to sound their alarums, and call attention to them, and all the alarums, when so prepared, will be sounded simultaneously if the communicator of any one apparatus is turned away from its resting position, that is, at its blank character (or –|–) to the next adjacent character, letter A, for instance, or letter C or E, or any others, whereby occasional or temporary magnetism will be excited in the several volatic magnets of the different apparatuses; and every person having charge of an apparatus, or hearing the alarum thereof beginning to sound, must go to the apparatus, and after due pause and attention to the manner in which the alarum is sounded he must then draw out the head O, which will remove the voltaic magnet away from the piece of soft iron X of the alarum, and bring it opposite the piece of soft iron V for the escapement, and then the apparatus will be ready for use for giving signals in the manner already fully described. And note, as the manner of sounding the alarums admits of considerable diversity by making pauses in the ringing, and varying those pauses, such variations may, by previous concert, serve to convey prefatory information as to the intention of the series of signals which are about to be begun, or to denote which of the intermediate apparatuses is to expect to receive signals, and from which terminal apparatus they will be given If the occasional magnetism is only excited for a moment and then discontinued, the fly wheel *y* may be stopped by its pin and detent when it has made only one turn, and that will produce a certain number of blows of the hammer, and then after a pause another like sounding may be made;

or if the magnetism is kept up a little longer, the fly wheel may be allowed to turn twice round before it is stopped, or thrice, so as to vary the manner of sounding as well as by varying the pauses.

And whereas another former patent was granted to the said William Fothergill Cooke by Her present Majesty, bearing date at Westminster, the eighteenth day of April, one thousand eight hundred and thirty-eight, for Improvements in Giving Signals and Sounding Alarums at distant Places by means of Electric Currents transmitted through metallic Circuits, and whereof the Specification stands enrolled in the Chapel of the Rolls, and in that Specification it was, amongst other matters, explained, and was claimed at the conclusion of that Specification under the head designated part F, in reference to the sounding of alarums, how the angular motion of a magnetic needle, that is produced by an electric current transmitted through coils surrounding a space wherein that needle is included, can be caused to disengage the detaining detent or stop of any sufficiently clock or watch work alarum, so as to allow the wheelwork thereof to be put into motion by the mechanical force and action of its own mechanism, in order to sound the alarum by action of that mechanism. And although an alarum can be sounded in that manner by the application of a very slight force for the purpose of removing the detent, nevertheless, as it is essential to that mode that the magnetic needle should exert the whole of the force requisite for that purpose, part of our present improvements now about to be described is for sounding an alarum by aid of the angular motion of such magnetic needle, when the deflecting force thereof is only sufficiently strong to cause a slight angular motion of that needle, even although the needle of itself should not have sufficient force to produce any sensible mechanical action. This improvement is effected by the addition of a hammer F, Figure 17, Sheet IV., which is moveable about a horizontal axis as a center of motion, and which hammer is lifted by means of pins in a wheel *v*, which is turned regularly round by the maintaining power of the clockwork to which it belongs with a continual motion, so that by the pins pressing in succession upon the tail or short end of the hammer F, its head will be caused to strike blows at regular intervals, but a stop *b* is fixed in a suitable suitable position to check the descent of the hammer, and it strikes its blows upon that stop *b*, except when the alarum belonging to the said clockwork is to be sounded. The clockwork may be of any ordinary construction urged by a maintaining power, and regulated by a pendulum or otherwise, so as to keep constantly going; and if it is adapted to give a speed

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of two revolutions of the wheel *v* in a minute, when there are four pins in that wheel *v*, the hammer F will strike eight times in every minute, on the stop *b*; and immediately beneath the head of the hammer F the detent D of the alarum part of the clock is situated, by which detent D the wheelwork of that alarum is detained and prevented from sounding; but by striking on the stop *b* the hammer F is prevented from descending far enough to come in contact with that detent D, and therefore the blows of the hammer have no effect thereon, unless some piece of metal is interposed between the hammer F and the detent D, and then the blow of the hammer on the interposed body would be communicated to the detent D so as to depress the same sufficiently to release the wheelwork of the alarum, and then the alarum will be sounded by the action of its own mechanism. The said interposition of a piece of metal between the hammer F and the detent D is effected by the upper end of the magnetic needle G, when the same is caused to perform an angular motion about its centre by action of an electric current as aforesaid, and however slight the deflecting force of the needle may be, if it is sufficient to produce so much angular motion of the needle as to interpose its upper end between the detent D and the hammer F, it will suffice for sounding the alarum, because it has only to transmit to the detent D the blow of the hammer which was before inoperative thereon. The manner by which the requisite angular motion of a magnetic needle is obtained by means of an electric current, having been fully explained in the said former Specifications, need not be repeated. And it is obvious that other machinery actuated by a maintaining power with forcible motion, and capable of regulating the speed of its own motion, may be made to perform the duty above ascribed to clockwork in alternately raising and letting fall a hammer, or otherwise striking, so as to cause the discharge of a detent in consequence of the interposition of the end of a magnetic needle, or else of any hard substance which may be moved or cause to be moved by an electric current, whether a magnetic needle or a piece of iron attracted by temporary magnetic attraction, so as to become interposed between the body so moved by machinery and the detent of the alarum. And although our aforesaid improvements have been herein-before described as if the aforesaid occasional magnetism in the voltaic magnets W would always be excited by an electric current excited by a voltaic battery, yet it is not essential that the electric current should be so excited, for if an electric current is caused by any means to pass through the coils round the magnet W, occasional magnetism will be excited in such magnet by such current, and all the

effects herein-before described as arising from the aforesaid excitement of occasional magnetism, by means of an electric current excited by a voltaic battery, will follow in the same manner from an excitement of a like continuation of occasional magnetism by an electric current excited by other means.

By the further improvement now about to be described, a magneto-electric machine is substituted for a voltaic battery, for the purpose above mentioned, and the same may under some circumstances be a more convenient agent, as requiring comparatively little or no care and attention.

Figure 18, 19, 20, Sheet IV., is a magneto-electric machine, which may be of ordinary construction. W^1 is a temporary magnet of a similar description to the magnet W herein-before described, and the same is fixed upon an axis *a* in suitable proximity to the permanent magnet W^2. Such being the position of the parts, it will follow, from the well known laws of magneto-electricity, that while the temporary magnet W^1 is at rest with either of its poles opposite to either of the poles of the permanent magnet W^2, no electric current will be excited in the coils of wire round the temporary magnet W^1 by the proximity of that magnet to the permanent magnet W^2; but let the temporary magnet W^1 be moved by revolution of its axis, so as to change its said supposed position of parallelism to the permanent magnet W^2 into any other position relatively to such magnet, a momentary electric current will be excited in the coils round the temporary magnet W^1 (supposing them to be a complete metallic circuit) at the moment the change of position takes place, and the electric current so excited might be caused to excite momentary occasional magnetism in the magnet W, by which occasional magnetism so excited all the same effects would be produced, and all the same consequences would follow, as would have followed from the excitement of a like continuation of occasional magnetism by an electric current excited by a voltaic battery. Such being the case, it is obvious that the descriptions hereinbefore contained in reference to Figure 1, 2, 3, 4, Sheet I., relative to the use of electro-magnetism for purposes of telegraphic communication, so far as the same may be applicable to the use of electro-magnetism of only momentary duration, are capable of being easily applied to the use of magneto-electricity for the same purpose, so that further descriptions in that respect are unnecessary. The difference between the use of electro magnetism, as hereinbefore described, and that of magneto-electricity as now being described, consists therefore in the momentary duration of the latter as contrasted with the continuous

action of the former. The practical effect of this difference is, that whereas by electro-magnetism a distinct and available signal is obtained by each action, and one by each reaction of the escapement wheel, on the other hand by magneto-electricity an available signal is obtained by the reaction alone, because the action of the occasional magnetism upon the escapement wheel is merely momentary, and does not admit of the signal being prolonged for a sufficient time to be intelligible, consequently the revolving dial, hereinbefore described as giving 24 signals under the influence of electro-magnetism, would, if submitted to the influence of magneto-electricity, according to our present improvement, give only twelve signals. The above particulars being understood, it may easily be explained how magneto-electricity is made available as a means of exciting occasional magnetism; the occasional magnetism being, as already described, excited by a change of the position of the temporary magnet W^1 relatively to the permanent magnet W^2, it is obvious that, in the particular instrument now under description, such occasional magnetism must be excited primarily by means of the motion of the axis *a*, by which alone such relative position of the temporary magnet can be changed. For the purpose of acting upon the axis in a convenient manner it is made to terminate in a small cog wheel *k* working into a large cog wheel K. The large cog wheel may be considered as performing an office nearly similar to the communicator hereinbefore described, for it is divided into twelve equal parts by twelve pins projecting from one side of its rim, each pin representing one of the twelve signals which the apparatus is capable of giving, and being suitably marked accordingly. The cogs in the two wheels are so arranged that a motion of the large wheel K through one of its twelve divisions, (that is to say, so that any one of its pins being at first opposite to any given point, the wheel is moved till the next pin becomes opposite to the same point) the axis of the temporary magnet will thereby be caused to perform half a revolution, so as by changing the relative position of the said temporary magnet, and consequently by exciting momentary occasional magnetism, to give by reaction one signal as hereinbefore mentioned, and so also as to replace the temporary magnet in a suitable position for a repetition of the process. But inasmuch as the temporary magnet has performed only half and not an entire revolution, the position of its poles relatively to those of the permanent magnet has become reversed consequently further mechanism is necessary for the purpose of causing the next electric current, which may be excited as aforesaid, to flow in the same direction as before, and not in a contrary direction. This ob-

ject is attained by interposing a disc p between the magnet W^1 and the small cog wheel k. A simple form of the disc might be a solid disc of brass or copper, containing merely a narrow strip of wood or other non-conducting material extending from side to side through its centre, so as to divide the whole disc into two solid semicircular insulated pieces of metal, or else the disc may be (as shown in Figures 18, 19, 20), merely coated by plates of metal insulated from each other by an interposed piece of wood; whichever form may be adopted, the end of one of the coils is to be fastened to one of the pieces or plates of metal, and the end of the other coil to the other piece, so that the ends of the two coils may be insulated from each other, and that the end of each may terminate in a distinct metallic piece or plate forming part of the said disc. The arrangement is such that whenever the two poles of the temporary magnet W^1 are placed in either direction opposite to the poles of the permanent magnet W^2, the two pieces or plates of metal of the disc p, and consequently the ends of the coils connected with them as aforesaid, are respectively in necessary connection with the two springs z, z, (viz., one of such pieces or plates of metal with one spring, and the other with the other spring), and the said springs with the buttons and wires belonging to and connected with them (form one continuity of metal so as to combine the said coils and the continuations thereof into one metallic circuit capable of transmitting an electric current upon a change of the position of the temporary magnet W^1 as aforesaid. But when by the means hereinbefore described the axis a is caused to perform half a revolution as aforesaid, the same half revolution of the axis occasions also half a revolution of the disc p, and the arrangement is such that although at the end of such half revolution of the said disc the metallic pieces or plates thereof are still placed in such positions as to complete the continuity of the metallic circuit, nevertheless, there is occasioned by such half revolution of the disc a reversal of the springs z, z, with which the metallic pieces a plates were before in contact, consequently by the reversal of the springs the aforesaid reversal of the poles of the temporary magnet W^1 is neutralized, and the electric current is on every excitement thereof, as aforesaid, transmitted in the same direction from the springs z, z, into the wires communicating therewith. And it has been already explained that the exhibition of the characters which denote signals may be made by a moveable index, or hand like the seconds' hand of a clock, pointing to characters on a fixed dial, instead of a moveable dial d, as represented in the apparatus, Sheet I. A moving hand may be preferred as being lighter and more readily put in

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motion than a moving dial, but when a hand and fixed dial is used the communicator shall be a counterpart thereof, having its characters fixed in a circle with a moveable index to point out them, instead of having its characters on a moveable circle with a fixed index to point to them, as is represented in Sheet I., and already described.

Sheet III. represents an apparatus for effecting the same purposes as that already described, but constructed with a moveable hand to point to characters on a fixed dial, and with a communicator suitable for that mode of indicating the characters. And whereas it is proper for the person who is giving signals by aid of the communicator to keep his eye upon the dial of his own apparatus (whether it be a moving dial or a moving hand), in order to observe and keep watch whether the signals which he intends to give are all truly exhibited, and that his communicator and his dial concur truly in exhibiting the same characters, it will greatly facilitate such observing and watching of the progress of the dial or hand if the circular motion of the communicator is made concentric with and round about that of the dial or hand, which may be done by making the moveable circle of the communicator a circular ring fitted to move around the circumference of the dial which occupies the interior of such ring. The apparatus represented in Sheet III. is constructed in that manner. And whereas it has been hereinbefore described that the resting position of the apparatus when no telegraphic communication is going on is a period of inaction of the occasional or temporary magnetism of the voltaic magnets, it should be understood that the same is not a necessary condition, for the apparatus may be constructed so as to remain at rest during the excitement of the occasional magnetism, which must in that case be kept steadily maintained during all the time of the intervals between making telegraphic communications by the apparatus. The apparatus represented in Sheet III. is constructed in that manner, And whereas, according to the description hereinbefore contained, although the attractive force attendant upon the excitement of occasional or temporary magnetism in the voltaic magnets is caused to produce the action requisite for giving signals, nevertheless that action is always followed by reaction by the force of a reacting weight or spring, which is overcome by the attractive force of the magnetism when the same is excited, but on the cessation of the magnetism then that reacting force operates to give the next succeeding signal. It should be understood that the same is not a necessary condition, for the apparatus may be constructed to employ two voltaic mag-

nets for exerting attractive force alternately, by exciting occasional magnetism first in one voltaic magnet and then in the other, in order that a piece of soft iron, situated between the two may be attracted and moved first one way by one magnet for giving one signal, and then the contrary way by the other magnet for giving the next succeeding signal, without any reacting spring. The apparatus represented in Sheet III. is constucted to operate in that manner. It requires for that purpose to have three long conducting or telegraphic wires, 21, 22 and 23, whereof one wire 21 extends by a direct course from one pole of the battery, at one terminal apparatus, to the contrary pole of the battery at the other terminal apparatus, without forming any coils around any of the voltaic magnets. The other two telegraphic wires 22 and 23, extend from the two voltaic magnets in one terminal apparatus to the two voltaic magnets in the other terminal apparatus, that is, one of those two wires, 22, makes coils around the right-handmost voltaic magnet of each of the two terminal apparatuses, and the other of those two, 23, makes coils around the left-handmost voltaic magnet of each of the two terminal apparatuses. Both wires, 22 and 23, are occasionally coupled together at their two ends, and the coupled ends are connected with the poles of the batteries at the two terminal apparatuses, viz., to the contrary pole of each of those batteries to that pole thereof to which one end of the wire 21 is connected. The metallic circuit which is then formed includes all the three long telegraphic wires 21, 22 and 23, and the electric current which is transmitted in one direction through that circuit is divided between the two coupled wires 22 and 23, and occasional or temporary magnetism is then excited in all the voltaic magnets at the same time; but this is not always the case, for, at other times, one or other of the two wires 22 or 33 is disconnected at one or other of its ends (not both) from the batteries, and then that wire ceases to form part of the metallic circuit, and the voltaic magnets, around which that wire forms coils (being one of the two magnets in each apparatus), will cease to be excited, leaving the other of those two magnets excited. For instance, if the wire 23 is disconnected at one of its ends, leaving the fellow wire 22 connected at each of its ends with the two terminal batteries, then the electric current that is transmitted through the wire 22 will excite occasional magnetism in the right-handmost voltaic magnet of each of the apparatuses, whereby the several pieces of soft iron in those apparatuses will all be attracted towards the right hand; but, on the contrary, if the wire 22 is disconnected at one of its ends, leaving the fellow wire 23 connected at

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each of its ends with the two terminal batteries, then the electric current that is transmitted through the wire 23 will excite occasional magnetism in the left-handmost voltaic magnet of each apparatus, whereby the several pieces of soft iron in those apparatuses will all be attracted towards the left hand. The conditions being premised, the construction of the apparatus represented in Sheet III. may be thus described :—Figure 11 is a plan of one terminal apparatus, and Figure 12 the other terminal apparatus ; Figure 13 being an intermediate apparatus, which, in order to simplify the description, may for the present be supposed not to exist, but that the two long telegraphic wires 22 and 23 extend from Figure 11 to Figure 12, as is shewn by the mere double lines without colour, which pass over Figure 13 without any connection with that Figure. The two terminal apparatuses, Figures 11 and 12, are exactly alike, although those two Figures are drawn rather different, in order to explain interior or exterior parts ; and Figure 14 is a vertical section of both or either apparatus, to shew the interior mechanism. The wooden box or case of the apparatus is shaped somewhat like a small writing desk, for when the case I is placed on a table or horizontal plane, the upper side of the case forms an inclined plane or surface on which the revolving circular ring K of the communicator appears surrounding the fixed dial *c*, whereon the characters are marked, and to which the moveable hand *d* points. A handle *q* is fixed to the revolving ring K, and projects upwards and outwards therefrom in a convenient manner for applying the hand or a finger thereto in order to turn it round ; and *s* is a small pointer which projects inwards from the handle *q*, in order to point to divisions which are marked around the fixed rim J, about which the ring K revolves as its centre of motion ; and the same characters around the dial *c*, to which the hand *d* applies and points in order to indicate the signals, also serve for directing, by aid of the pointer *s*, where the handle *q* of the communicator K shall be turned to and stopped, in order to communicate each signal, and as the communicator K is turned steadily and deliberately round by its handle *q*, the hand *d* will be turned round at the same rate by the action of the occasional magnetism and the clockwork, so as to keep the point of the hand *d* always directed towards the pointer *s*, that is, provided that the apparatus acts correctly, but if it does not, the fault cannot escape observation, the hand *d* will not be directed towards the pointer *s*, as it ought to be. The clockwork is contained in the box beneath the dial. A, A, Figure 14, are the plates of the frame of the clockwork ; B the spring barrel for the maintaining power, which acts by a cord or

chain and fusee (which fusee does not appear in Figure 14, and with a train of three wheels and three pinions to turn the axis *a* of the escapement wheel *b*, the end of which axis *a* passes through the dial plate *c*, and has the hand *d* fixed upon the extreme end of it. The pallets or anchor of the escapement is affixed to an axis *c* as their centre of motion, beyond which a lever arm projects out from the anchor, see Figures 13 and 14, and the piece of soft iron V is affixed to the extremity of that lever arm in a proper position between the pole pieces *u*, *u*, of the two voltaic magnets W, W, *W*, *W*, whereof one magnet is supported by a cross bar *n*, fixed at one side of the two clock plates *a*, *a*, and the other magnet to a like cross bar *n* at the other side. Those magnets are (or may be) the same as represented at Figure 5, Sheet I., and hereinbefore described. Each magnet consisting of two cylindrical pieces of soft iron, with a number of coils of wire around it, the two pieces so coiled being united together at one end of each by a connecting piece of iron *w*, and two such magnets being used; they are supported by screwing their respective connected pieces *w* to the supporting cross bar *n* of the frame. The pieces of iron *u*, *u*, which are fixed to the ends or poles of each of the magnets W, W, *W*, *W*, are opposite the other, leaving such space between them as is suitable for the reception of the piece of soft iron V of the escapement, and for the extent of motion which that piece of iron requires to have, in order that the escapement may act properly, to permit the teeth of the escapement wheel *b* to escape half a tooth a time, in the usual manner of clock escapements, excepting that the teeth of the escapement wheel *b* and those parts of the pallets which act therewith are cut with a much greater slope in respect to each other than is usual in well made clocks, in order that the effort which the maintaining power of the spring B exerts to turn the escapement wheel *b* round may operate to urge the pallets first one way and then the the other with so much force as will keep them effectually in motion from right to left and back again from left to right alternately, without any chance of their resistance when left to themselves being ever able to stop the motion of the wheel *b*. But when occasional magnetism is excited in both the voltaic magnets, beween which the piece of soft iron V is included, the attractive force of that magnetism, although operating upon that piece V at opposite sides thereof, will nevertheless act so much more powerfully on that one side of the piece V which is nearest the magnet on that side, as to effectually detain the said piece V from moving, notwithstanding the tendency of the wheel *b* to move the same. For as every magnet acts

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with a very great increase of attractive force upon a piece of iron which is so very near to it as almost to touch over and above the attractive force which the same magnet can exert on the same piece of iron when it is removed to a small distance, it follows that when by action of the escapement the piece of iron V has been moved as far as it can go towards either of the voltaic magnets, for instance the right-handmost (both being equally excited), it will then stand so very near to the pieces of iron *u*, *u*, at the poles of that right-handmost magnet, that although it does not actually touch them, nevertheless the attractive force of those pieces *u*, *u*, will most completely overpower all the effort that the escapement can exert to move the piece V back again or towards the left hand, and that notwithstanding the other or left-handmost magnet is at the time exerting its attractive force upon the piece of iron V to draw it towards the left hand, because the said attractive force is so much lessened by the distance at which it acts upon the piece V, that although acting in concert with the tendency of the escapement, it will not be able to move the piece V in opposition to the very much stronger force wherewith the other or right-handmost magnet, owing to its proximity, holds the piece V towards the right, wherefore the piece V will be effectually detained, and the escapement wheel *b*, together with the hand *d*, prevented from turning, but will stand motionless pointing to the same character on the dial *c* so long as the excitement of both magnets is continued. And it is to be understood respecting the action of the apparatus, Sheet III., so long as the spring B of clockwork continues wound up, that in all cases when the hand is so kept standing motionless pointing to the character on the dial *c*, it will be when both magnets are excited with occasional or temporary magnetism at once as above described, although when the hand is so resting it will be sometimes with the piece of iron V attracted or detained by attraction towards the right-hand voltaic magnet, and at other times towards the left-hand voltaic magnet. But whenever the said occasional magnetism of that voltaic magnet against or towards what the piece of iron V is so held attracted and detained (suppose for instance the right-handmost) ceases for a moment, then the said piece V, being no longer attracted towards the right, will obey the influence of the escapement and allow the same to let one-half tooth of the wheel *b* escape, so as to turn the hand round from one character to the next, for that said influence causes the piece V to retreat to the left away from the said right-handmost voltaic magnet, against which it was before held

and detained, and to approach very suddenly towards the opposite or left-handmost voltaic magnet which does continue to be excited, and whereof the attractive force towards the left, although slight, acts in aid of the said influence of the escapement; but the united tendency of the said attractive force to the left, together with the tendency of the escapement, was not sufficient to move the piece V towards the left away from ths right-handmost voltaic magnet, to which it was near, until the magnetism thereof ceased. That cessation may be only momentary, and the same right-handmost voltaic magnet may be excited afresh, but it will not in consequence recall the piece of iron V back again towards it, notwithstanding that the escapement now tends to move it back to the right, because the left-handmost voltaic magnet now attracts the piece of iron V with the greatest force in consequence of the nearness thereof; and in detaining the piece V from moving will keep the escapement wheel and the hand standing still until the temporary magnetism of the left-handmost voltaic magnet is caused to cease for a moment, and then the piece V, being no longer attracted thereby, will move away therefrom towards the right and allow the escapement wheel *b* to turn another half tooth and turn the hand round to another character, and so on every time the occasional magnetism of either voltaic magnet is caused to cease for a moment the escapement wheel is allowed to move round half a tooth. And the requisite making and breaking of the circuit which will produce such momentary cessations of the occasional magnetism of first one voltaic magnet and then the other, suitably for the above purpose, and which it is the office of the communicator to perform, may be thus explained :—The revolving circular ring K has teeth around its circumference which act in those a small pinion, on the axis whereof a small circle or wheel *h* is fixed. The number of teeth on the ring K exceeds those of the pinion as many times as there are teeth in the escapement wheel *b*; (in the present instance that is fifteen teeth, the dial being divided into that number, or thirty divisions and characters); hence the small circle *h* is caused to make one-half turn for each character. It has a piece of bone or wood fitted into a large notch in its circumference, and the rest of the circumference is metal, which metal is always kept connected with the pole of the battery by a wire z^1. Two springs, 22 *z* and 23 *z* apply with their extremities in contact with opposite parts of the circumference of the circle *h*, and those springs are always in connection with the ends of the two long telegraphic wires 22 and 23, which, as before mentioned, form coils around the several voltaic magnets, one wire around the right-handmost, and the other wire about

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the left-handmost of those magnets. As the circle *h* turns round one or other or else both of the springs 22 *z*, 23 *z*, form contact with the metal of that circumference, and thereby they connect one or other or else both the telegraphic wires 22 and 23 with the pole of the battery. The piece of bone in the said circumference applies sometimes to one spring 22 *z* sometimes to the other, 23 *z*, but never to both, wherefore sometimes one telegraph wire, 22, and at other times the other telegraph wire, 23, becomes disconnected during a moment from the battery. The course of the several wires is so evident from the Drawing as to require no further explanation. Whenever either apparatus is left standing still, and no telegraphic communication is making by it, then the handle *q* of that communicator K must be turned upwards, to point by its pointer *s* to the blank character on the dial, as is the case in Figure 13, and then the circle *h* stands with the metal part of its circumference in contact with both the springs 22 *z*, 23 *z*, and consequently that end of both telegraphic wires 22 and 23 are connected with the pole of the battery at that terminus. The other apparatus, Figure 11, is represented in the act of giving a signal, the revolving circular ring K of its communicator being turned round by its handle *q* until its pointer *s* is directed to the character on the dial, which character may denote the conclusion of a word, and that the commencement of a succeeding word in the telegraphic communication is about to be given. The hand *d* points to the same character, and so does also the hand of the other apparatus, Figure 13, and indicates to the person stationed at that apparatus that he is to note down that character as a signal given to him. The circle *h* in Figure 11 now presents the metal part of its circumference to the two springs 22 *z*, 23 *z*, and therefore that end of both telegraphic wires are connected with the battery at that terminus, and the opposite ends, Figure 13, of the same two wires 22, 23, being also connected with the battery at that terminus, it follows that all the voltaic magnets (right hand as well as left hand) will be excited, and, as already explained, both terminal apparatuses, Figures 11 and 13, will detain their pieces of iron V and the pallets of their escapements from allowing their respective escapement wheels *b* and hands *d* from moving. When a succeeding signal is to be given (suppose character letter G, for instance), then the handle *q* is to be moved steadily round until that handle and its pointer *s* gets round to point to that said letter G on the dial; and as the circle of the communicator K moves round the handle *d* will accompany it with a corresponding motion, and also the other *d*, Figure 11, will move at the same rate, so as always to point to the same charac-

ters one hand as the other. This advancing motion of the two hands step by step alike is produced by momentary cessations of the excitement of magnetism in the several volatic magnets alternately in the right-hand ones and in the left-hand ones, as already fully explained, that alternation being according as the piece of bone in the circumference of the revolving circle *h* is turned towards a left-hand spring 23 *z*, or towards a right-hand spring 22 *z*, for to whichever side and spring that bone is for the time turned it will cause a momentary discontinuance of the excitement of the voltaic magnet on that same side; but that discontinuance is only momentary, because the handle *q* makes no stop in passing round from one character to another which is to be indicated, but is moved steadily round; and as the circle *h* then revolves quickly its piece of bone runs past the end of that spring to which in turn it presents itself in an instant, and whenever the handle *q* and revolving circle K of the communicator is brought to rest it will be with its pointer *s* exactly over a division on the fixed circle J thereof, and with the pointer *s* opposite to a character on the dial, in which case the piece of bone will be either at the lower or else at the upper part of the circle *h*, out of the way of contact with either of the springs 22 *z* or 23 *z*, which will both be in contact with the metal of the circle *h*, and consequently both telegraphic wires 22 and 23 will be connected with the batteries, and all the voltaic magnets will be excited. And note, owing to the larger portion of the circumference of the circle *h* being metal and only a small portion thereof of bone, it follows that the contact of one spring with the metal will always take place before the other spring quits contact with the metal, by which means the re-excitement of the voltaic magnets on one side will always precede the discontinuance of the excitement of those on the other side, in order to insure that it shall never happen that neither are excited, for if that were to happen the piece of iron V would not be detained, but would allow the escapement wheel to move the pallets and piece of iron V backwards and forwards and turn round together with the hand; and at any time, if the apparatus is going decidedly wrong, that fault will be shewn by the hand beginning to move round of itself. And as to sounding alarums, the clockwork for so doing is disposed in the same plates A, A, with the other clockwork, as is shewn in Figures 12 or 14, wherein S is the main spring for the maintaining power of the alarum; H, its bell; *v*, its serrated wheel which moves the hammer *y* for ringing that bell. O is the head of a slider, which pushed in catches the hammer to stop it from ringing, but when drawn out allows the hammer to act and sound the alarum when-

ever the ordinary stop detent of the alarum is disengaged, which is done by a pin or by pins in one of the wheels *j* of the clockwork; wherefore in order to sound the alarum after preparation has been made by drawing out the head O, then the handle *q* of the communicator K being turned all round to allow the escapement wheel to turn round, that motion must bring one of the pins of the wheel *j* to the detent of the alarum, so as by releasing that detent to let off the alarum for sounding. But whenever that sounding is not desired the head O is pushed in. And note, if at any time the hand *d* gets wrong so as not to correspond to the pointer *s*, the communicator K can be set right by turning it round in the backwards direction until the pointer *s* gets round opposite to the hand *d*, which will not move backwards. And as to the intermediate apparatus, Figure 13, it is on the same construction as the two terminal apparatuses, Figures 11 and 12, except in having two of the small revolving circles *h* and *h* 1 in place of one of such circle, and there is a spring 22*y*, 23*y*, to each of those circles. The telegraphic wires 22 and 23 take the courses drawn and colored in Sheet III. for connecting with the intermediate apparatus, Figure 13. The spring 22*y* connects by a short wire with the left-hand end of the coils around the right-handmost voltaic magnet, and the other spring 23 *y* connects by a wire with the left hand of the coils around the left-handmost voltaic magnet. The telegraphic wire 22, from the terminal apparatus, Figure 11, joins by the wire 22 *n* to the right-hand end of the coils around the right-handmost voltaic magnet; and the other telegraphic wire 23 from the other terminal apparatus, Figure 11, is connected by a wire 23 *n* with the metal of the revolving circle *h*, and the telegraphic wire 22 from that other terminal apparatus, Figure 12, connects by the branch 22 *l* to the other revolving circle *h* I; also the telegraphic wire 23 from the terminal apparatus, Figure 12, connects by a branch with the revolving circle *h*; when thus connected the intermediate apparatus, Figure 13, is adapted to give signals by turning the handle *q* of its communicator K round, or if that handle *q* is turned upwards as in Figure 13 and left standing there, the apparatus will be prepared for receiving signals in the same manner as either of the terminal apparatuses, Figures 11 or 12 would do; but no battery is necessarily required for the intermediate apparatus, Figure 13, the two batteries at the terminal apparatuses, Figures 11 and 12, serving for the whole system shewn in Sheet III.; or the same intermediate apparatus, Figure 13, may also be used as a portable apparatus to be connected with any part of the long line of the tele-

graphic wires 22, 23, where the means of connection have been provided, which in the case of a road or a railway may be at the mile posts. 40 represents the top of such a post. The wires 22, 23, are conducted up into two holes therein, where the continuity of each of those wires when in ordinary use is dependent upon the contact of two pairs of springs, 50, 51, 60, 61, which by closing together complete the metallic continuity of each of the two telegraphic wires 22 and 23; but whenever the portable apparatus, Figure 13, is to be applied to the long telegraphic wires at such a mile post 40, its box or case is placed thereon in Figure 13, and two wooden wedges which project downward from that case are inserted into the said holes in the top of that post 40, so as to enter between the two pairs of springs 50, 51, and 60, 61, in order to wedge in between and separate the two springs of each pair one from the other, and thereby break the metallic continuity of each of the long telegraphic wires. But the said wedge pieces have a pair of metal plates applied to each side of each wedge, with wires 22 *l*, 22 *n*, 23 *l*, 23 *n*, ascending up into the apparatus from each metal plate; those plates having no metallic connection one with the other, but being in contact with the springs 50, 51, 60, 61, they, with their said ascending wires aforesaid, connect the parts of the apparatus with the long telegraphic wires in the same manner as already described of Figure 12, when considered as an intermediate apparatus. Figure 6, Sheet III., represents the escapement of the apparatus contained in that Sheet on a large scale, to shew how the pallets and the teeth of the escapement wheel *b* should be sloped in order to qualify them for performing in the manner already explained, and Figure W shews how two pieces of soft iron V, V, may be fixed to the pallets themselves in order to be attracted alternately in contrary directions by voltaic magnets W, W, and *W*, *W*, disposed at opposite sides of those pallets. Figure H shews a different kind of escapement, which may be used in the apparatus contained in Sheet III. if the same were to be constructed in a simple manner without any spring barrel for maintaining power or train of wheelwork to turn the escapement wheel *b* round together with the hand; but the force for that purpose must be wholly derived from the attractive force of the occasional magnetism, and the pallets are formed as represented, so that by being alternately moved one way and then the other, they will act on the teeth of the wheel *b* to turn it round. The piece or pieces of soft iron which are to be operated upon by the said attractive force may be applied either as represented in Figure 12 or Figure W. And for telegraphic communications between places which are too distant for an elec-

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tric current to be transmitted all the way with sufficient vigour, to be certain in its operation, a chain of such apparatuses as hereinbefore described must be established to communicate one to another through the whole distance, in which case what has been called the distant terminus of one apparatus will be situated close by the commencing terminus of the next apparatus, and the signals there received from one apparatus must be sent forwards by the next apparatus, and so on, all which requires no explanation, because it is well known in the usual system of telegraphic communication, and forms no part of our present Invention. And the same may be said of the telegraphic language or system of signals and their significations. Those systems which are well known and in use for other telegraphs may be used, or they may be modified, but they form no part of our Invention.

Having now described our said improvements, I, the said Charles Wheatstone, for myself and for the said William Fothergill Cooke, do hereby declare that the new Invention whereof the exclusive use is granted to us by the said Letters Patent of the twenty-first day of January, one thousand eight hundred and forty, consists in the following particulars: And note, whereas the particulars of improvements which were claimed by me and William Fothergill Cooke in the former Specification, by virtue of our Patent of the twelfth day of June, one thousand eight hundred and thirty-seven, were therein enumerated as "firstly," "secondly," and so in due order up to "ninthly;" and also whereas the several particulars of improvements claimed by the said William Fothergill Cooke in another Specification, by virtue of Letters Patent granted to him on the eighteenth of April, one thousand eight hundred and thirty-eight, were therein enumerated as Part A, Part B, and so on in due order up to Part F, I shall, in order to avoid confusion therewith, enumerate the several particulars of improvements which we, Charles Wheatstone and William Fothergill Cooke, now claim in the Specification by virtue of our said Letters Patent of the twenty first of January, one thousand eight hundred and forty, under the heads or titles Part G, Part H, and so on as follows, and represented in Figures 1 to 5, Sheet I., and Figures 11, 12, and 13:

Part G is the improvement, hereinbefore fully described, of employing the attractive force of occasional or temporary magnetism which is excited in soft iron by means of electric currents transmitted through metallic circuits, for the purpose, by alternately exciting and ceasing to excite such magnetism, of producing, by intervention of suitable mechanism such as hereinbefore described (but the construction of which

mechanism may be greatly varied), any such motion of a hand or other indicator for pointing to characters on a fixed dial as will qualify that hand or indicator for exhibiting those characters in a suitable manner for giving signals, or of producing such motion of a dial with characters thereon as will qualify that dial for exhibiting those characters in a suitable manner for giving signals, or employing the said attractive force for the purpose of governing, directing, and controlling, by the intervention of suitable mechanism, such as hereinbefore described (but the construction of which mechanism may be greatly varied), the motion, as aforesaid, of such hand or other indicator, or of such dial, when the force or power requisite for producing that motion is derived from or is assisted by action of an independent maintaining power, so that the motion is only directed, governed, or controlled by the said attractive force of occasional or temporary magnetism, and that whether the aforesaid electric currents are excited by means of voltaic batteries, or any kind of magneto-electric or other machine or apparatus capable of producing such currents.

Part H is the improvement hereinbefore described of the mechanism which we have called a communicator for alternately making and breaking any such metallic circuit as is suitable for the transmission of electric currents in spiral convolutions around masses of soft iron, so as to excite occasional or temporary or voltaic magnetism in such masses whenever the said circuit is made, and cessation of that magnetism whenever the said circuit is broken, in order by such alternate making and breaking of the circuit in rapid succession (without necessity for pause) as many times in succession as is required to obtain alternate excitement and cessation of the said magnetism, for the purpose of producing (according to the preceding Part G of our improvements) motion of hand or a dial, or else of regulating such motion as is stated in the said preceding Part G.

Part I is the improvement hereinbefore described, and represented at Figure Sheet IV., of the Drawings hereunto annexed, for sounding alarums in distant places by aid of machinery, which is kept in continual motion by any suitable maintaining power, that motion being kept regulated as to speed by any suitable kind of regulator, and which machinery at regular intervals, by raising a hammer or other like means, strikes with sufficient force for releasing the detaining detent of the wheelwork to its alarum, provided that the blow was struck on that detent, but which it is prevented by some suitable stop from doing, unless the end of a magnetic needle is interposed between such detent and the

hammer, so as to transmit the blow thereof to the detent and release the same in order to sound the alarum, such interposition of the end of that magnetic needle resulting from its angular motion caused by the transmission of an electric current through multiplying coils of conducting wire surrounding the space wherein such needle is contained; or, in lieu of a magnetic needle, to be moved with angular motion by an electric current for the purpose of so interposing a solid body between the hammer and the detent as aforesaid, the requisite motion for so interposing may be derived from the attractive force of occasional magnetism excited in a voltaic magnet by an electric current, and acting on a piece of iron connected in any suitable manner with the solid body which is to be interposed by such occasional magnetism.

Part J is the improvement hereinbefore described, and represented in Figure 22, Sheet II., whereby the angular motions which may be given by electric currents to magnetic needles, which are moveable in spaces surrounded by multiplying coils of wire foaming metallic circuits, through which such electric currents are transmitted, is caused to give motion by the intervention of suitable mechanism to a hand or dial for exhibiting characters in a suitable manner for giving signals.

Part K is the improvement hereinbefore described, and represented in Figures 18, 19, and 20, Sheet IV., for employing the attractive force of occasional or temporary magnetism, which will be excited in soft iron by transmission of electric currents through metallic circuits for the purpose, by action of such attractive force on suitable mechanism, of sounding alarums, when such electric currents are produced by magneto-electric apparatus instead of by voltaic batteries.

Part L is the improvement hereinbefore described, and represented in Figures 11, 12, and 13, Sheet III., whereby the revolving apparatus which we call a communicator (as stated and claimed in Part H) is rendered concentric with the dial or hand whereby the characters are exhibited, the revolving motion of such concentric communicator being coincident with that of the hand or dial when exhibiting characters.

Part M is the improvement hereinbefore described, and represented in Figures 11, 12, and 13, Sheet III., whereby one of the long telegraphic wires being appropriated to the voltaic batteries by which electric currents are to be produced, and two other long telegraphic wires being provided to transmit the current in one direction (but the current divided between those two), the same battery is enabled to serve apparatuses at great distances asunder without necessity for employing a battery at each apparatus, and therefore a portable apparatus may be

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applied to any part of the length of the telegraphic wires, as shewn by Figure 12, without the inconvenience of carrying a battery therewith.

Part N is the improvement hereinbefore described, and reprrsented in Figures 11, 12, and 13, Sheet III., whereby the rest of cessation of motion in the hands or dials, by which characters are exhibited, is derived from the continued transmission of an electric current through the metallic circuit, which extends throughout the whole system of apparatuses; and also whereby momentary cessations of such current through one or other of the two wires, both of which usually transmit the current in one direction (but the current divided between those two), such momentary cessations are made to produce, by intervention of suitable mechanism, motions of a hand or dial, and other parts adequate for the purposes of exhibiting signals and sounding alarums.

In witness whereof I, the said Charles Wheatstone, have hereunto set my hand and seal, this Twenty-first day of July, One thousand eight hundred forty.

CHARLES (L. S.) WHEATSTONE.

WILSON.

AND BE IT REMEMBERED, that on the Twenty-first day of July, in the third year of the reign of Her Majesty Queen Victoria, the said Charles Wheatstone came before our said Lady the Queen in Her Chancery, and acknowledged the Instrument aforesaid, and all and every thing therein contained and specified, in form above written. And also the Instrument aforesaid was stamped according to the tenor of the Statute made in the fifty-fifth year of the reign of His late Majesty King George the Third.

Inrolled the Twenty-first day of July, One thousand eight hundred and forty.

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A.D. 1870. April 8. N° 1044.
VARLEY'S SPECIFICATION.

SHEET 1.
4 SHEETS.

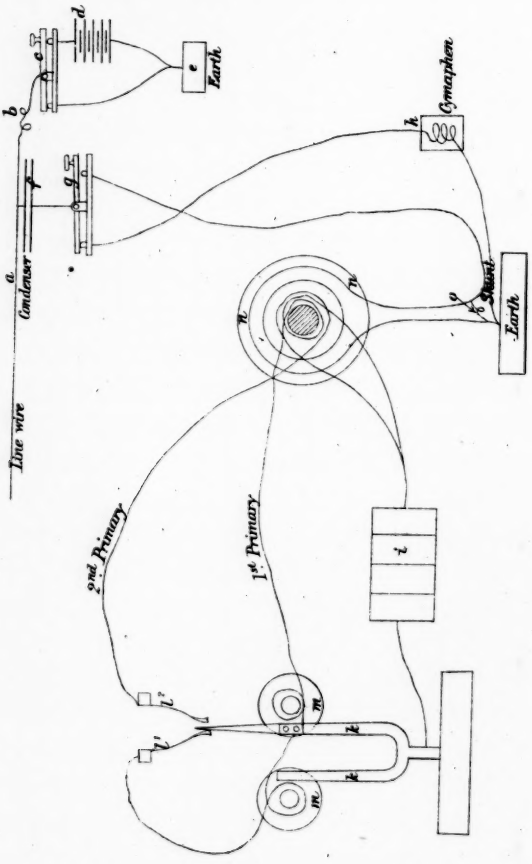

FIG. 1.

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A.D. 1870, April 8. N° 1044.
WARLEY'S SPECIFICATION.

SHEET 2
4 SHEETS.

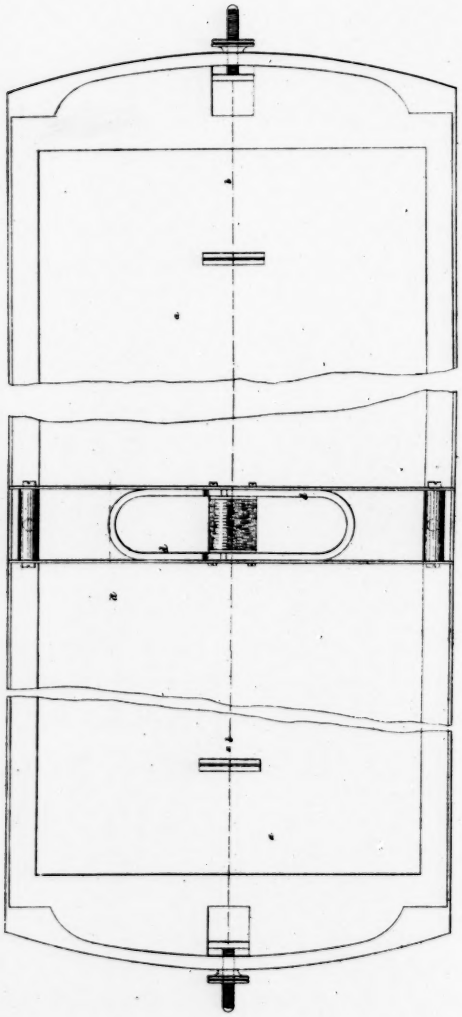

FIG. 2.

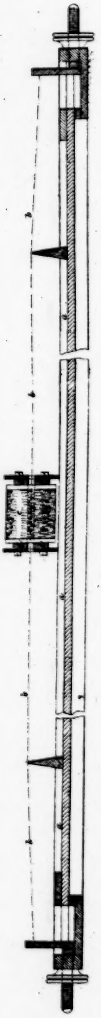

FIG. 3.

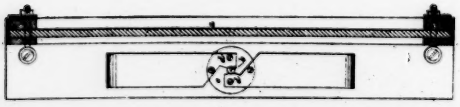

FIG. 4.

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A.D. 1870. April 8. N° 1044.
VARLEY'S SPECIFICATION.

SHEET 3.
4 SHEETS.

FIG. 5.

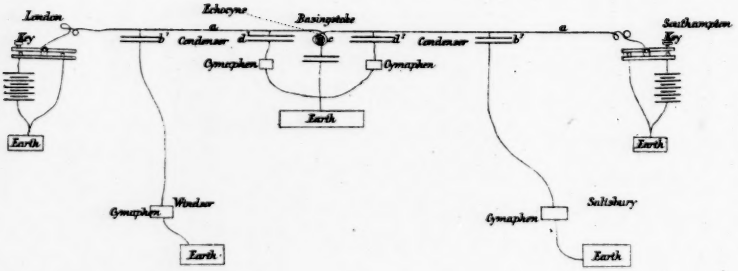
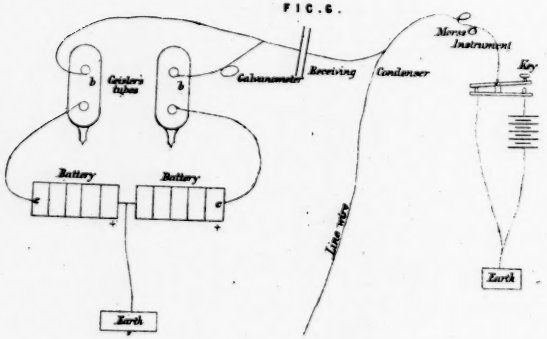


FIG. 6.



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SHEET 4.
4 SHEETS.

A.D. 1870. APRIL 8. N° 1044.
VARLEY'S SPECIFICATION.

FIG. 7.

FIG. 8.

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DEFENDANT'S EXHIBIT VARLEY PATENT, W. C. W., EX'R.

[INTRODUCED RECORD, PAGE 66.]

A. D. 1870, 8TH APRIL No. 1044.

ELECTRIC TELEGRAPHS.

LETTERS PATENT *to Cromwell Fleetwood Varley, of Beckenham, in the County of Kent, for the invention of "Improvements in Electric Telegraphs."*

Sealed the 7th June, 1870, and dated the 8th April, 1870.

PROVISIONAL SPECIFICATION *left by the said Cromwell Fleetwood Varley at the Office of the Commissioner of Patents, with his Petition, on the 8th April,* 1870.

I, Cromwell Fleetwood Varley, of Beckenham, in the County of Kent, do hereby declare the nature of the said Invention for "Improvements in Electric Telegraphs," to be as follows: —

This Invention has for its object the increase of the transmitting power of telegraph circuits by enabling more than one operator to signal independent messages at the same time upon one and the same wire to and from independent stations.

In working land lines it is usual to produce the signals by means of the passage of a current of electricity producing magnetic action, as in the Morse or Hughes instruments, or chemical action, as in the Baines machines.

By my invention I superpose upon the currents used for working the ordinary telegraphs rapid undulations or waves which do not practically alter the mechanical or chemical power of the ordinary signal currents, and by new apparatus hereinafter described these undulations are made to produce distinct and independent audible or other signals so long as these undulations are produced, whether ordinary signal currents be flowing or not.

As a rough mechanical illustration of the way in which I propose to pass two sets of elastic signals simultaneously and in either direction through the same line wire without interference I will suppose a rope stretched over two distant pulleys by means of weights at each

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end; if the near weight be raised the distant one falls. In this way signals are transmitted by the connecting rope, which may be called current signals; if now two small pulleys capable of rising and falling rest upon the rope between but near to the supports they will simply rotate when the rope is shifted backwards and forwards; if now an operator at one end strike the rope, vibrations or waves will be produced which will cause the other small pulley to dance or make vibration signals. Consequently the operator who shifts and the operator who strikes the rope can each produce independent signals on one and the same rope. Suppose the rope to travel over several fixed pulleys the operation of shifting the rope will produce distinct current signals from end to end of the line as before, but between each fixed pulley vibrations can be produced, and so a number of intermediate stations can communicate independently of each other and independently of the current signals through the line.

With this mechanical simile the following will be more easily understood.

The way in which I carry my electric invention into operation is as follows: —

An electro-magnet offers at the first moment great opposition to the passage of a current of electricity, and therefore it may be considered as partially opaque to the transmission of very rapid alternations or electric waves. I attach to the line at desirable parts condensers. In the first instance I will assume only two condensers, one at each end, attached near each end of an ordinary telegraph line. The first or communicating station produces in its condenser rapid charges and discharges; these add to and take from the line a number of small electric impulses without affecting the mean magnetizing power of the currents through the line. These impulses charge and discharge the second condenser at the other end.

These undulations in the second condenser can be utilized in the following manner: —

1. If the condenser be made of paper and metal foil the rapid charges and discharges produce a musical sound.

2. If those rapid alternations be made to pass round a helix containing an iron rod a musical sound is produced.

3. If these currents pass round a helix containing a magnetized

harmonium tongue the currents make it vibrate audibly if the currents be properly timed, and the effect is increased if a feeble current of air be passing the tongue. By adding tubes of proper length and sounding boards and other appliances for communicating vibrations the power of the signal is increased.

4. By placing the magnetized tongue of a musical comb between the poles of an electro-magnet with only a small iron core, or inside a coil, it is made to vibrate whenever these undulations are passing.

5. Another method of producing sound from the undulations consists of stretching a music wire through hollow helices; the currents magnetize and demagnetize the tone, this wire being also placed between the poles of permanent magnets. Harmonious currents cause this wire to vibrate. In some cases it may be useful to employ inharmonious currents to stop or silence the vibrations. The two latter methods will only speak when vibrations or harmony with the tongue are made to pass, and consequently in some cases two or more distinct sets of vibrations can be made to act on two or more sets of apparatus differently tuned, and to permit of several distinct communications to be transmitted simultaneously upon the same section of a single line wire. By introducing between the receiving condenser and a Morse or other ordinary receiving instrument a current reverser keeping time with the vibrations, these alternating currents are made to flow through the receiving instrument in one direction, and are then competent to work the Morse or other ordinary receiving instrument.

6. When it is desirable to subdivide the vibrating sections of a line an electro-magnet, or, what is better, two electro-magnets are inserted in the circuit, and a condenser may with advantage be placed between the circuit and the earth connecting the condenser with the circuit between the two electro-magnets. In this way, without interfering materially with the ordinary signals through the line, the vibrating sections are separated from each other, by withdrawing the iron cores from the electro-magnets, or short circuiting the electro-magnets the vibrations are passed through to the next station.

7. Another method consists of inserting a reflecting galvanometer between the condenser and the earth (or between the line and the

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condenser); the vibratory or secondary signals can be read off by observing its vibrations.

8. Vibrations are rendered sensible by placing a movable iron bar between the poles of an electro-magnet or inside a helix, and one or both of its ends between the poles of permanent magnets; the latter are covered with brass or any non-magnetic matter; the vibration currents cause it to vibrate between the poles of the electro or permanent magnets, and so produce distinctly audible sounds.

9. There are other methods of utilizing these superposed vibrations, such as connecting to the condenser an electrometer like that of Milner or Peltier. An intermediate Morse or other such line instrument would cut off the vibration signals or reduce them much; this opposition of the intermediate electro-magnet may be cut off by connecting the terminals of a condenser to the circuit on each side of the magnet.

There are several methods of producing these vibrations in the wire: —

1st. If a tuning fork be placed between the poles of an electro-magnet with a spring contact so arranged that when at rest the battery current flows through the electro-magnet the latter will attract the tuning fork and break the circuit; the magnetism then ceases and the tuning fork springs back and renews the circuit; in this way it keeps vibrating so long as the battery is in action. A secondary wire around this magnet produces currents in opposite directions, and by placing this secondary wire in circuit with the line wire the necessary vibrations are produced.

2d. The secondary wire may be connected between the earth and the condenser attached to the line wire; this method does not add to the resistance of the main circuit, and is therefore preferable.

3d. A tongue similar to those used in harmoniums is made to vibrate by air between contact points, and so connect the condenser alternately with the battery and the ground, and so produce the alternations, or it may be made to connect the condenser alternately to the + or — pole of a battery whose opposite poles are connected to the earth.

4th. A magneto machine rapidly rotating will do the above duty equally well if its speed of rotation be controlled by a good gov-

ernor. The tuning fork and vibrating tongue arrangement can be set to and can keep up any desirable rate of vibrations. The ordinary telegraph keys and switches are used for connecting the various parts of the apparatus together. In constructing the dry paper condensers it is best to dip the paper in varnish and attach metal leaf (such as gold, silver, or copper) to the paper, and lay these metal-coated papers between metal foil.

The double-speaking apparatus of Dr. Gintl, or of Firschen, can be used on lines working with the above-described vibrations. When these are used I prefer inserting a hollow helix between the double speaker and the line, and by inserting iron rods in this helix the difficulty arising from the inductive capacity of the line is almost wholly removed. This is a new improvement, and will render these apparatus actually useful instruments.

SPECIFICATION *in pursuance of the conditions of the Letters Patent, filed by the said Cromwell Fleetwood Varley in the Great Seal Patent Office, on the 8th October* 1870.

To all to whom these presents shall come, I, Cromwell Fleetwood Varley, of Beckenham, in the County of Kent, send greeting.

Whereas Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Eighth day of April, in the year of our Lord One thousand eight hundred and seventy, in the thirty-third year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said Cromwell Fleetwood Varley, Her special licence that I, the said Cromwell Fleetwood Varley, my executors, administrators, and assigns, or such others as I, the said Cromwell Fleetwood Varley, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "Improvements in Electric Telegraphs," upon the condition (amongst others) that I, the said Cromwell Fleetwood Varley, my executors or administrators, by an instrument in writing

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under my, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

Now know ye, that I, the said Cromwell Fleetwood Varley, do hereby declare the nature of the said Invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say: —

This Invention has for its object the increase of the transmitting power of telegraph circuits by enabling more than one operator to signal independent messages at the same time upon one and the same wire to and from independent stations.

In working land lines it is usual to produce the signals by means of the passage of a current of electricity producing magnetic action, as in the Morse or Hughes instruments, or chemical action, as in the Baines machines.

By my Invention I superpose upon the currents used for working the ordinary telegraphs rapid undulations or waves which do not practically alter the mechanical or chemical power of the ordinary signal currents, and by new apparatus hereinafter described these undulations are made to produce distinct and independent audible or other signals so long as these undulations are produced, whether ordinary signal currents be flowing or not.

As a rough mechanical illustration of the way in which I propose to pass two sets of electric signals simultaneously and in either direction through the same line wire without interference, I will suppose a rope stretched over two distant pulleys by means of weights at each end. With such an apparatus, if the near weight be raised the distant one falls, and in this way signals may be transmitted by the connecting rope, which may be called current signals. If now two small pulleys capable of rising and falling rest upon the rope between but near to the supports they will simply rotate when the rope is shifted backwards and forwards; but if now an operator at one end strike the rope vibrations or waves will be produced, and will cause the small pulley at the other end to dance, and so vibration signals

may be given. Consequently the operator who shifts and the operator who strikes the rope can each produce independent signals on one and the same communicating cord. Suppose the rope to travel over several fixed pulleys the operation of shifting the rope will produce distinct current signals from end to end of the line as before, but between each fixed pulley and the next to it vibrations can be produced, and so a number of intermediate stations can communicate independently of each other and independently of the current signals through the line.

With this mechanical simile the following will be more easily understood.

The way in which I carry my electric invention into operation is as follows: —

Condensers are attached to the line at the places where the wave signals are to be communicated and received. In the first place, let us assume only two condensers, one at each end, attached near each end of an ordinary Morse telegraph circuit. The first or communicating station to make a signal produces in its condenser rapid charges and discharges by means described; further on these add to and take from the line a number of small electric impulses without affecting the mean magnetizing power of the ordinary Morse currents through the line. These impulses charge and discharge the second condenser at the other end, and this condenser is coupled with a receiving instrument which is sensitive to these undulations and renders them apparent by sound or otherwise.

Figure 1 is a diagram of the instruments at one of the stations of such a line; *a* is the line wire, I will suppose it to be an ordinary land line wire 50 miles long and suspended in the usual way; *b* is the Morse instrument, *c* the sending key for the Morse signals, *d* the battery in connection with this key, and *e* its earth connection; *f* is a condenser of about 3 micro-farads, one armature of which I couple with the line wire and the other with a key *g*, which when not depressed puts the condenser in communication with the wave signal receiving instrument *h*, which I call a "cymaphen"; this instrument is shown at Figures 2, 3 and 4. The key *g* when depressed for sending a wave signal puts the condenser in connection with the apparatus by which such waves are generated; this apparatus con-

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sists of a battery i; ten quart cells of Daniel's battery will be suitable. One pole of the battery i is connected with the tuning fork k; this fork may conveniently be of such dimensions as to make 200 vibrations in a second. l^1, l^2 are two platina pointed contact-making springs, capable of fine adjustment by means of screws. The spring l^1 when the fork is at rest is in metallic contact with it or with a metal arm attached to it, and the spring l^2 is removed just out of contact. The current from the battery i then passes in the coils of the electro-magnet m, the poles of which have between them the two horns of the tuning fork. The coils of this magnet may be about 3½ inches long and 1½ inches diameter, and of No. 16 (B. W. G.) silk-covered copper wire. When the current is flowing through the coils of the electro-magnet the horns of the fork k are drawn apart and the spring l^1 loses its contact; then as the attraction of the magnet ceases the horns of the fork spring back; this remakes the contact, and so a continual tremor is communicated to the tuning fork. In the same circuit with the electro-magnet there is at n a primary coil wound upon a bundle of iron wires as a core, and on the same core but wound in the opposite direction is a second primary coil which is in connection with the spring l^2, so that currents pass alternately in the two primary coils, and at each alternation the polarity of the core is reversed. On the core there is also another or secondary coil, in which currents are induced by the changes of polarity of the iron core. One end of this secondary coil is connected with the earth, and the other when a wave signal is to be sent is by the key g put in connection with the condenser f, and produces in it rapid charges and discharges. The core may conveniently consist of a bundle of thin soft iron wires, 1 inch in diameter and 32 inches long. On the centre of the bundle is wound for a length of eight, the first primary coil consisting of four layers of No. 16 silk-covered copper wire. Over this is wound the second primary coil consisting also of four layers, and outside this again is wound the secondary coil, consisting of eight layers of No. 24 silk-covered wire. The ends of the bundle composing the core are folded over so as completely to enclose the coils. A small resistance coil o, or a condenser of about two micro-farads, is placed between the poles of the secondary coil to take off the violence of the shock, so that the operator shall not be incon-

venienced. The wave signal receiving instrument *h* is shown in plan at Figure 2, in longitudinal section at Figure 3, and in transverse section at Figure 4. It consists of an iron frame containing a sounding board *a* over bridges, at the ends of which a hard drawn iron or steel wire *b* is stretched from one end to the other; this wire is about four feet and six inches long between the bridges; it is of No. 14 gauge, and is strained so as to sound the same note as the tuning fork of the sending instrument. This wire passes through a hollow helix *c*, three inches in length, $\frac{1}{6}$ of an inch internal diameter and $1\frac{1}{2}$ inches external diameter. The helix is wound with No. 35 B. W. G. copper wire insulated with silk. This coil is attached to the frame supporting the sounding board, but does not touch the latter. Two horse-shoe magnets *d* are placed one on each side of the wire. The currents magnetize the wire inside the helix, and so cause it to be attracted and repelled from one magnet to the other. When the wire is properly tuned so as to vibrate synchronously with the apparatus at the distant end, making the alternations in the current, the sound from very feeble currents is distinctly audible. A piece of felt or leather resting against the wire is sometimes used to "damp" the wire and stop its vibrations as soon as the impulses cease. A small piece of metal similar in dimensions to a gold five-franc piece may be made to rest by a spring lightly against the sounding board somewhere near its centre. When the vibrations of the latter are powerful enough to make this piece of metal dance, the sound is increased in power four or five times by this little disc or sound reinforcer, or the sound may be augmented by clipping on to the wire near the helix a disc of about the size of a penny piece of thin sheet metal; this causes the vibration of the wire to produce a greater disturbance in the air than it otherwise would, and a louder sound is perceived. By attaching a stethescope to the sounding board for the reader to rest his ear against, very feeble sounds are rendered sufficiently audible; I prefer to use a Scott Allison's stethescope. The sounding board may be replaced by a strained diaphragm or drum-head, on which one of the bridges over which the wire is strained is supported; this arrangement gives a better sound with very feeble currents, but with moderate currents the sounding board appears to have the advantage. Two sets of wave signals may be transmitted and received simultane-

ously through the same wire, and independently of the current signals if a sufficient difference be made in the periods of the two sets of waves. Thus, if waves of 200 vibrations in the second, and waves 850 or 900 vibrations in the second, be simultaneously transmitted and received by two separate cymaphens, the one adjusted to the slow, and the other to the rapid vibrations, they may be separately read, as the vibrations which affect the one are inoperative on the other. This arrangement is not applicable when working long distances, as the rapid waves would in a long distance be lost.

Figure 5 is a diagram illustrating the arrangements I make when the wave signals are used to communicate between intermediate or branch stations without interfering with the working by ordinary instruments of the main line; *a* is the line wire, say between London and Southampton, and through it it is desired that the intermediate station, Basingstoke, shall without interference with the through messages be able to communicate to and fro with the branch stations, Windsor and Salisbury. At these branch stations I provide wave signal apparatus such as already described in respect to Figure 1, coupled with condensers b^1, b^2, at the places where the branches run into the main line. At the intermediate station, Basingstoke, I divide the line wire into two sections (as far as the wave signals are concerned) by introducing at *c* an instrument which is opaque to these waves, whilst it allows the ordinary long current signals to pass freely. This opaque instrument *c* I call "echocyme," and on either side of it I connect with the line wire a condenser d^1, d^2, and wave signalling apparatus, as already described. An electro-magnet offers at the first moment great opposition to the passage of a current of electricity, and may be considered as nearly opaque to the transmission of very rapid alternations of current or electric waves. The "echocyme" may consequently be a simple electro-magnet, or what is better is to wrap an induction coil with two wires so as to form one continuous coil; this is put into the line circuit. The junction between these coils is connected to the one armature of the condenser, whose other armature is connected to the earth. The momentary action of a current on passing through one wire charges the condenser. The secondary action upon the other wire checks the

current that the condenser would have sent on through the other wire on to the remainder of the main line circuit; by varying the size of the condenser according to the nature of the line and currents employed a nearly absolute stopper of the vibrations signals is produced. The coil which I have used for this purpose has the following dimensions: iron bundle one inch in diameter, length of coil 8 inches, and wound with No. 26 insulated copper wire to a diameter of 2 inches. The condenser connected between the "echocyme" and the earth in the case which I have taken for illustration should be of about $\frac{1}{10}$ of a micro-farad. At the termini Morse or other ordinary instruments may be used.

There are various ways in which the wave signal receiving apparatus may be constructed, although that which I have already described I prefer; thus the condenser itself may be the receiving instrument.

If the condenser be made in the following manner the rapid charges and discharges will produce a musical sound. Sheets of tinfoil (for example, one foot square) are separated by one or more sheets of thin dry paper; the 1st, 3rd, 5th, &c. sheets are joined together; the 2nd, 4th, 6th, &c. also joined together. The odd numbered sheets are connected to a binding screw or terminal, and the even numbered sheets to another terminal. Such a condenser consisting of from 20 to 50 sheets will be found to be much agitated and to produce a loud note with 500 alternations of current per second if the potential be 50 to 100 votts.

In constructing the dry paper condensers the following method seems to answer best: — Very thin uniform paper is dipped in shellac varnish coated on one side with gold leaf and then dried. The non-gilt surfaces of 2 sheets of paper are put together so as to leave the gilt surfaces outside; the tinfoil plates are placed outside of these and built up in the usual manner, connecting the 1st, 3rd, 5th, 7th, &c. plates to one armature of the condenser, the 2nd, 4th, 6th, 8th, &c. being joined to the other armature of the condenser. If the rapid alternations of current be made to pass round a helix containing an iron rod, the iron rod will issue a feeble but distinct sound. The rod used may be $\frac{1}{8}$th of an inch in thickness, 18 inches in length, and covered to a diameter of one inch with No. 35 insulated

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copper wire. This arrangement requires strong currents. If the currents pass round a flat coil in which a magnetized harmonium tongue is placed, the currents will act upon it like the needle of a galvanometer and cause it to vibrate. The sound is increased by causing a feeble current of air to pass the tongue. If a steel tongue, similar to one of those used in a musical box, be magnetized and placed inside a helix of fine wire, and its lip is placed between the poles of a powerful permanent magnet, the alternating currents will cause the tongue to vibrate and produce a musical sound so long as the alternations are operating. By coating a wire, strained, as is shown in Figures 2 and 3, near the coil, with a short tube of gold or platinum, and letting a light spring formed of the same metals rest against the wire, a relay is produced, which bringing into operation a local battery can be used to increase the sound or to relay on the signals to another line.

A thick music wire, much thicker than those used in pianofortes, is found to give the best results for sound. A thin wire is thrown into greater oscillation than a thick one, and admits of being utilized for visible signals in the following way : — A steel wire of about No. 40 gauge is stretched through the helix in front of a very narrow slit. A flame is passed behind the slit, but the light coming through is checked by the wire; the moment, however, the wire is put into vibration light passes, a lens is placed in front, and by it a magnified image of the luminous slit is projected upon a white screen so long as the wire vibrates. Vibrations are rendered sensible by placing a movable iron bar between the poles of an electro-magnet or inside a helix, and one or both of its ends between the poles of permanent magnets; the latter are covered with brass or any non-magnetic matter. The vibration currents cause it to vibrate between the poles of the electro or permanent magnets, and so produce distinctly audible sounds.

Another method of utilizing these alternations is by introducing between the receiving condenser and a Morse or other ordinary receiving instrument a current reverser keeping time with the vibrations; these alternating currents may be made to flow through the receiving instrument in one direction, and are then competent to work the Morse or other ordinary receiving instrument. Or a simi-

lar result may be obtained by the arrangement shown at Figure 6, which consists in connecting the receiving condenser to two "Geisler's" vacuum tubes *a* and *b*; the latter are connected with voltaic batteries C, Z, consisting of a large number of elements. The one tube *a* is connected to the "positive pole" of a battery whose "negative pole" is connected to the earth. The second tube *b* is connected to the "negative pole" of a battery whose "positive pole" is to earth. These batteries must have nearly power enough to make a current pass through the tubes; for example, supposing three hundred cells of a battery be able to leap across the exhausted tube 290 should be used with each tube. When a positive current arrives it will help the battery whose positive pole is connected to the earth and cause a current to pass through its tube *b*. The next instant the current is reversed; this causes a current to pass through the other tube *a*; in this way an electric valve is produced separating the positive from the negative currents, and producing a rapidly intermittent current in one direction only. If a reflecting galvanometer be enclosed in the circuit formed by the batteries and the tubes the wave signals will be indicated by it.

Another method of producing an electric valve for separating the positive from the negative currents, is illustrated by Figure 7, and consists in connecting, say, 5 cells of Daniel's battery with 3 cups containing dilute sulphuric acid with platinum plates joined up so as to form 3 decomposition cells in series. Between the battery and the 3 cups is inserted the galvanometer or other instrument that is to be worked; the junction between the instrument and the cups or decomposition cells is connected to the condenser. The other junction between the battery and the decomposition cells is connected to the earth. The first action of the battery is to polarize the platinum plates when the current almost entirely ceases, the three pairs of polarized platinum plates balancing the 5 Daniel's cells. The moment a current arrives from the condenser it finds two channels open to the earth, — the one the battery, the other the decomposition cells. Suppose the positive pole of the battery to be in connection with the earth and a positive current arriving from the condenser, at first it divides itself, part going through the battery, part through the decomposition cells. The action of the current upon the latter

is to depolarize them, and they then immediately resist its flow. The next moment a negative current flows from the condenser, this negative current is assisted by the partly depolarized plates, and the battery and the former become repolarized. It is best to wrap the instrument, as the diagram shows, with two wires connecting the one with the cups, the other wire with the battery, and their junction with the condenser. The result is that whether it be a negative or positive current that is sent into this arrangement the action upon the instrument is the same, and thus out of alternating currents a continuous action is produced. The platinum plates for this purpose must be very small and very close together, to reduce as much as possible their inductive capacity and resistance.

Another method consists of inserting a reflecting galvanometer between the condenser and the earth (or between the line and the condenser); the vibratory or secondary signals can be read off by observing its tremor. The mirror of this galvanometer must be deadened by water or other damper, and it is best to produce the signals by interrupting the vibrations instead of the reverse. The vibrations keep the mirror oscillating, the image becomes spread out, and the light enfeebled. The moment the vibrations are cut off the light contracts. The effect is the "spread out" light is feeble, the "concentrated" is bright, and thus the signals can be flashed by long and short duration like the Morse alphabet.

Another method of utilizing these superposed vibrations is to connect to the condenser an electrometer like that of Milner or Pettier. A resistance coil of about 1,000 ohms is connected between the condenser and the earth as a shunt to the electrometer to prevent the Morse signals from affecting it to any sensible extent; or the wave signals may be read by the sense of touch. For this purpose I use a handle made of hard charcoal, and divided into two parts longitudinally. The parts are separated by a sheet of gutta percha, and are connected the one with the armature of the condenser, the other with the earth. The handle being moistened and covered with a rag wetted with weak salt and water is firmly grasped in the hand. An intermediate Morse or other such line instrument would cut off the vibration signals or reduce them too much; this opposition or opacity of the intermediate instrument is destroyed by connecting the ter-

minals of a condenser to the circuit on each side of the magnet. Thus, if I wish wave signals to pass a Morse instrument I couple the armatures of a condenser of 3 to 10 micro-farads with the line wire, one on either side of the Morse instrument. The working of the Morse line, if there are many instruments in circuit, is also in this way improved.

There are several methods of producing electric waves in the lines in addition to that already described. A tongue similar to those used in harmoniums is made to vibrate by air between contact points, and so connect the condenser alternately with the battery and the ground, and so produce the alternations, or it may be made to connect the condenser alternately to the + or — pole of a battery whose opposite poles are connected to the earth.

A magneto machine rapidly rotating will do the above duty equally well if its speed of rotation be controlled by a good governor.

The double-speaking apparatus of Dr. Gintl, or of Frischen, can be used on lines working with the above-described vibrations.

Figure 8 is a diagram of this arrangement. *a* is the line wire; *b*, *b*, the condensers; *c*, *c*, the cymaphens, wave signal transmitters, and parts connected therewith; *d*, *d*, are the current signal keys and batteries; and *e*, *e*, are the magnets of Dr. Gintl or Frischen's receiving instruments; and *f*, *f*, are their resistance coils. I prefer wrapping the magnets *e*, *e*, with 3 or 4 wires, using one wire between the key and the earth through its resistance coil, and the two or three wires joined into one circuit attached to the line wire. I insert a hollow helix between the double speaker and the line, and by putting iron rods in this helix the difficulty arising from the inductive capacity of the line is almost wholly removed; this is a new improvement and will render these apparatus actually useful instruments. The helix may conveniently be of No. 26 silk-covered wire and 10 inches long, with a diameter inside of 1½ inches, and outside of 4 inches; small iron rods are placed in this helix one by one until it is found that the finger-key does not affect the indicator of the home receiving instrument. By using these instruments, these apparatus together with cymaphens, as is shewn in Figure 8, three messages can be sent from end to end of such a circuit at the same time independently of each other; for this purpose the cymaphen key must

have a spring contact, so that the circuit between the condenser and the earth is never broken until the contact with the secondary coil is complete.

I would remark that in electric telegraphs the use of sound signals is not claimed by me and is not new; for example, in working step by step instruments in which a pointer should indicate the desired letter on a dial it has been common when the instrument is out of order and fails to indicate correctly to give sound signals; by its means such sound signals are read according to the Morse alphabet, a short sound such as the escapement of the receiving instrument makes when moving a few steps only representing a dot, and a long sound such as the escapement makes when moving over many steps representing a dash.

Having thus described the nature of my Invention, and the manner of performing the same, I would have it understood that I claim the construction of electric telegraphs in such manner that current signals and wave signals may be simultaneously transmitted through the same line wire, and may be rendered sensible at the receiving station by separate instruments, the one sensitive to currents of appreciable duration and the other to electric waves or vibrations.

I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving station a strained wire, a tongue, or such like instrument adjusted to vibrate in unison with the electric waves, and being magnetized by them oscillating to and from the pole or poles of a magnet in its vicinity.

I also claim in the construction of electric telegraphs the dividing a conducting wire into sections by instruments which I have called "echocyme," which allow current signals to pass freely but stop wave signals, so that whilst the wire is being used as a whole for through signals the sections into which it is divided may each or all be employed for the transmission of local messages.

I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the

receiving station a condenser consisting of thin sheets capable of being agitated by such waves.

I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving statian an instrument which on receiving such waves delivers a current of electricty to an indicating or receiving instrument suitable to be worked with ordinary current signals.

I also claim the combination with Dr. Gintl and Frischen's double-speaking apparatus of a hollow helix connected between the receiving instrument and the line wire, such helix having rods or pieces of iron inserted into it.

In witness whereof, I, the said Cromwell Fleetwood Varley have hereunto set my hand and seal, this Seventh day of October, in the year of our Lord One thousand eight hundred and seventy.

CROMWELL F. VARLEY. [L. S.]

DEFENDANT'S EXHIBIT, JOHNSON PATENT, GRAY'S MAGNET RECEIVER, W. C. W., EX'R.

[INTRODUCED RECORD, PAGE 66.]

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE.

To all Persons to whom these Presents shall come, Greeting:

This is to certify that the annexed is a true copy from the bound volumes of the library of this office of the Specification and Drawing in the matter of the English Letters Patent granted John Henry Johnson, July 29th, 1874, No. 2,646, for Transmitting Musical Tones by Electricity.

In testimony whereof, I, W. H. Doolittle, Acting Commissioner of Patents, have caused the Seal of the Patent Office to be hereunto affixed this seventeenth day of March, in the year of our Lord one thou-sand eight hundred and seventy-nine, and of the Independence of the United States the one hundred and third.

[SEAL] W. H. DOOLITTLE.

Acting Commissioner.

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A. D. 1874, 29TH JULY, No. 2646.

TRANSMITTING MUSICAL TONES BY ELECTRICITY.

LETTERS PATENT *to John Henry Johnson, of* 47, *Lincoln's Inn Fields, in the County of Middlesex, Gentleman, for the Invention of "Improvements in the Method of and Apparatus for Transmitting Musical Tones by Electricity."—A communication from abroad by Elisha Gray, of Chicago, County of Cook, State of Illinois, United States of America.*

Sealed the 23d October, 1874, and dated the 29th July, 1874.

COMPLETE SPECIFICATION *filed by the said John Henry Johnson at the Office of the Commissioners of Patents, with his Petition and Declaration, on the 29th July,* 1874, *pusuant to the 9th Section of the Patent Law Amendment Act,* 1852.

To All To Whom These Presents Shall Come, I John Henry Johnson, of 47, Lincoln's Inn Fields, in the County of Middlesex, Gentleman, send greeting.

Whereas I am in possession of an Invention for "Improvement in the Method of and Apparatus for Transmitting Musical Tones by Electricity," and have petitioned Her Majesty to grant unto me, my executors, administrators, and assigns, Her Royal Letters Patent for the same, and have made solemn Declaration that the said Invention is communicated to me from abroad by Elisha Gray, of Chicago, County of Cook, State of Illinois, United States of America.

Now know ye, that I, the said John Henry Johnson, do hereby declare that the following Complete Specification, under my hand and seal, fully describes and ascertains the nature of the said Invention and in what manner the same is to be performed in and by the following statement, reference being had to the accompanying Drawings and to the letters and figures marked thereon, that is to say: —

This Invention relates to a method of producing musical tones of any desired pitch at any point in an electrical circuit, and consists in transmitting a series of impulses of induced electricity of high tension, corresponding in number to the number of audible vibrations constituting said musical tone, through living tissue in contact with

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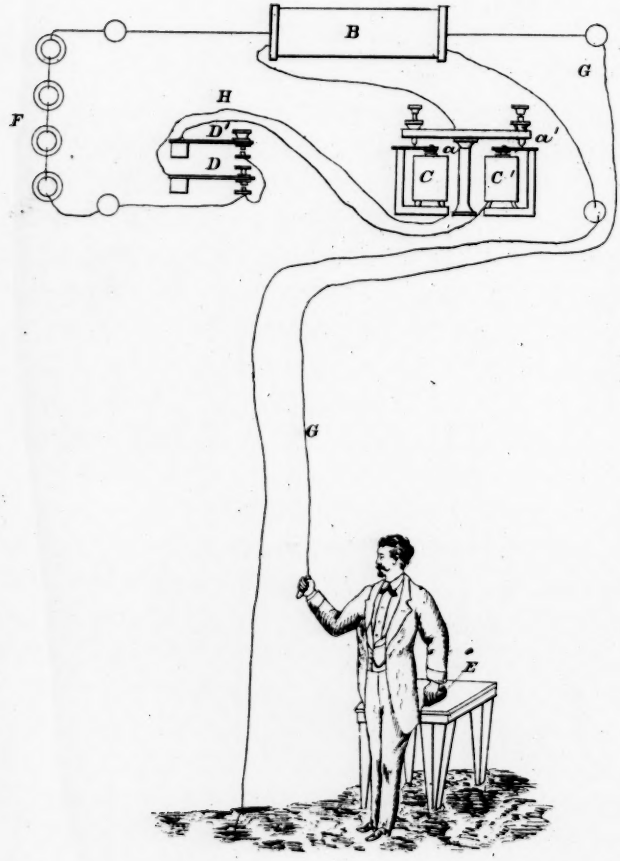
A.D. 1874. JULY 29. N°2646.
JOHNSON'S COMPLETE SPECIFICATION.

Sheet 2.
3 Sheets.

FIG. 3.



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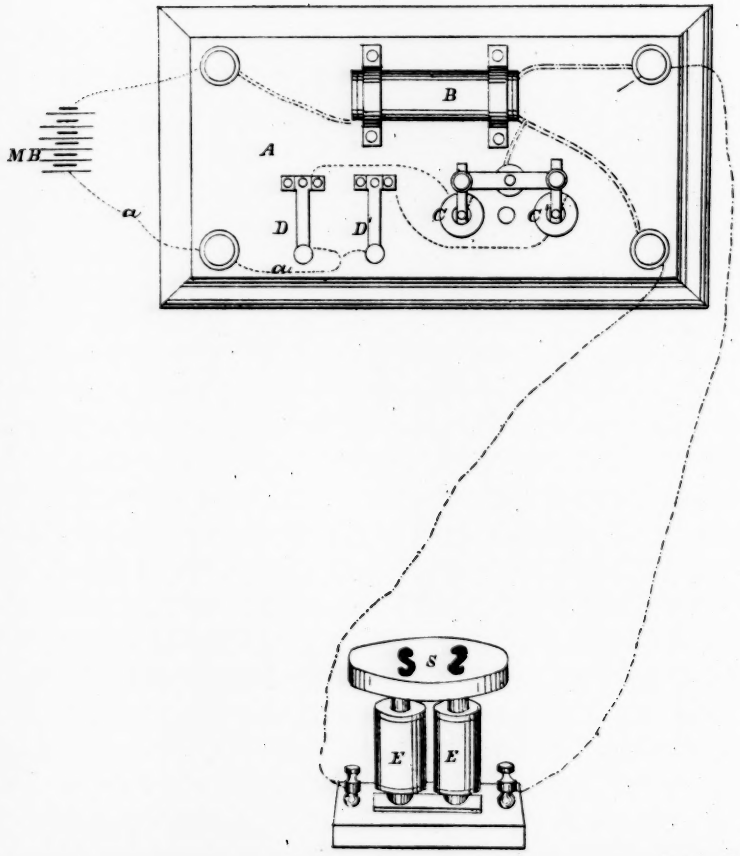
A.D. 1874. JULY 29. N°2646.
JOHNSON'S COMPLETE SPECIFICATION.

Sheet 3.
5 Sheets.

FIG. 4.



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any resonant substance, or through a coil surrounding a bar of iron or the core of an electro-magnet, the succession of currents being produced by an induction coil or other apparatus for inducing a secondary current, and being caused by the action of any suitable circuit interrupter situated in a primary circuit.

And in order that the said Invention may be fully understood, I shall now proceed more particularly to describe the same, and for that purpose shall refer to the several Figures on the annexed Sheet of Drawings, the same letters of reference indicating corresponding parts in all the Figures.

Figure 1 of the Drawings represents one form or plan of an electrical apparatus in which these improvements are embraced; Figure 2 is a front elevation of the same, and Figure 3 is a diagram shewing an arrangement of parts and circuits which may be employed in connection with these improvements.

A represents the base or frame of the apparatus; B is an induction coil of the usual form provided with the usual primary and secondary helices; C is an ordinary vibrating electrotome which when in action produces a musical tone, by the vibration of its armature and circuit breaking spring *a* of a pitch determined by its rate of vibration, which rate is dependent upon the length, stiffness, and adjustment of the spring attached to the armature of the electrotome; C^1 is another electrotome similar to the first with the exception that its spring a^1 is so adjusted that it produces when in action a musica tone of a different pitch from that produced by the electrotome C, owing to the different rate of vibration of its circuit breaking spring a^1. Other electrotomes may be provided having their vibrating springs so constructed and adjusted that when in action the series will produce tones extending through one or more octaves. These electrotomes are situated in the primary circuit of the induction coil B, and when the said primary circuit is broken by the vibration of the circuit breaking springs, secondary currents are induced in the secondary circuit of the said coil.

D, D^1, are telegraphic keys of the usual form placed in the primary circuit above referred to, which circuit is divided so that it passes through both keys and both electrotomes. The keys are used for making connection with the battery.

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Figure 3 shows the arrangement of the circuits; G being the secondary circuit extending from the induction coil B to the receiving station; F, the battery; and H, the primary circuit from the battery through the keys; D, D^1, magnets of the electrotomes C, C^1, and the primary circuit of the induction coil B. E represents a suitable resonant substance at the receiving station, and consists of a hollow cylinder of metal.

The method of operation of the apparatus is as follows: — On depressing either of the keys D, D^1, the primary circuit from the battery F will be closed through one of the electrotomes, and the spring or circuit interrupter of the latter will immediately commence to vibrate, producing a musical tone of a certain pitch dependent as before stated on the size and adjustment of the spring, and interrupting the primary circuit of the induction coil B. These interruptions will induce secondary currents in the secondary circuit of the said coil, which will correspond in number with the vibrations of the circuit interrupter, and the number of musical audible vibrations constituting the tone produced. Thus for example if the circuit interrupting spring vibrates one hundred and twenty-eight times per second, the tone produced is that known as the "fundamental C," and at the same time one hundred and twenty-eight terminal induced currents will be generated in the secondary circuit.

If now a person places himself in the said secondary circuit and brings his hand or any other part of his body in contact with any resonant substance which is a conductor of electricity so that the circuit is completed through it the said resonant substance being either the metallic cylinder shewn at E, or a plate of metal stretched above the body of a violin by metallic strings or a sheet of foil paper stretched over a metallic ring or any other suitable resonant substance, the impulses of electricity transmitted through the living tissue of the operator will from some cause not yet fully understood, produce a corresponding number of vibrations in said resonant substance, and a musical tone will be given forth of a quality dependent upon the character of the resonant substance, but of the same pitch as that produced by the vibration of the circuit interrupter at the transmitting end.

Instead of interrupting the primary circuit by vibrating automatic

electrotomes, and thereby inducing the secondary current of high tension which is transmitted to the resonant receiver, the necessary interruptions for this purpose may be effected by any mechanical device which will produce a sufficient number of interruptions per second to cause a musical tone.

The secondary coil may be dispensed with and the secondary currents induced in the primary coil, when the primary circuit is interrupted may be transmitted to the receiver for the purpose of producing the audible vibrations.

Another form of the apparatus is constructed as follows: — The transmission of sound is effected as in the apparatus above described by the conversion of electrical impulses of high tension through a secondary circuit into audible vibrations, but the apparatus is based upon the principle that an electrical current traversing a coil surrounding a bar of iron or the coil of an electro-magnet causes a slight elongation of the said bar or core, which elongations if they succeed each other with sufficient rapidity will result in a vibration of the bar, and the production of a musical tone. This apparatus is shewn at Figure 4, the transmitting apparatus being the same as in the apparatus before described, but the receiving apparatus as shown at E, consists of an electro-magnet placed in the secondary circuit; S represents a hollow cylinder of metal which is placed upon the poles of the electro-magnet and intensifies the sound.

The uses to which the apparatus may be applied are various. In telegraphing, for example, instead of transmitting messages by means of the Morse alphabet now in general use, tones of different pitch corresponding to the letters may be employed, which tones can be produced more rapidly than printed or impressed dashes can be made, and their duration would be shorter than the intermissions now required for producing dashes and dots in succession.

A very slight interval would be necessary between the tones to indicate the separation, and as dashes would be indicated by one tone, and dots by another, all signals would have the same length. Instead of using one tone for dashes and another for dots, signals could be devised consisting of tones of various combinations. These signals can soon be readily learned and read by any operator capable of distinguishing tones of different pitch, who by placing his ear in

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contact with the resonant substance, would cause the tones to be produced and still have both hands free to receive the message. By means of a type-writer an operator could record about eighty words a minute.

The amount of current which is necessary to produce the effect is almost unappreciable. Less than one hundredth part of the battery power now required enables audible signals to be transmitted over long lines. The apparatus can therefore be employed with advantage on submarine lines, and the rate of transmission over them can be thereby much increased.

As a telegraph apparatus it is simple, economical, and rapid in its operation.

The apparatus may also be employed to transmit tunes from one place to another, the vibrating pieces being properly pitched and sufficient in number, even the different parts of a musical composition each simultaneously played in different places may be transmitted to the same place, so that the whole will be there audible. In the latter case a separate circuit and transmitting and receiving apparatus will be required for each part of the musical composition, and it will be necessary to beat time by telegraph for each set of performances.

The apparatus can also be employed with advantage in studying the laws of acoustics.

Having now described and particularly ascertained the nature of the said Invention, and the manner in which the same is or may be used or carried into effect, I would observe in conclusion that what I consider to be novel and original, and therefore claim as the Invention is, —

First. The method of producing audible musical vibrations of any desired pitch in a resonant substance, which is a conductor of electricity by transmitting through living tissue in contact with said substance, a series of electrical impulses of high tension corresponding in number with said vibrations, substantially as and for the purpose herein-before described.

Second. The combination of an apparatus for producing a secondary current of electricity, a series of vibrating electrotomes, or other circuit breaking devices controlled by corresponding keys, and a resonant receiver arranged in a secondary circuit, substantially as

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T. A. EDISON.

Relay Magnets.

No. 141,777. Patented August 12, 1873.

Fig. 1.

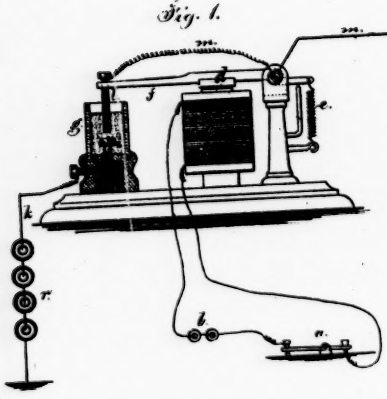
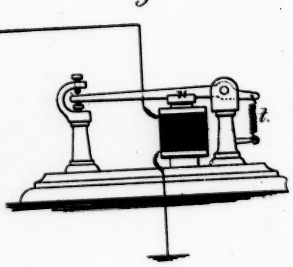


Fig. 2.



Witnesses, Chas. H. Smith, Geo. F. Tuttle.

Inventor, Thomas A. Edison, by Lemuel W. Serrell, atty.

and for the purpose herein-before described and illustrated by the accompanying Drawings.

Third. The arrangement of a series of two or more vibrating automatic electrotomes, whose vibrating circuit closers are so arranged as to produce tones of different pitch in combination with keys for controlling the same, substantially as herein-before described and illustrated by the accompanying Drawings.

Fourth. The method of producing musical tones by causing the vibration of a bar of iron surrounded by a coil of wire or the core of an electro-magnet by transmitting a series of induced currents through the coil surrounding said bar or coil, substantially as and for the purpose herein-before described.

Fifth. The combination of an apparatus producing induced secondary currents with a series of electrotomes or other circuit interrupters, and an electro-magnet arranged in the secondary circuit, substantially as and for the purposes herein-before described and illustrated by the accompanying Drawings.

In witness whereof, I, the said John Henry Johnson, have to this my Complete Specification set my hand and seal, the Twenty-ninth day of July, One thousand eight hundred and seventy-four.

J. HENRY JOHNSON. [L. S.]

DEFENDANT'S EXHIBIT EDISON RELAY MAGNET PATENT.

[INTRODUCED RECORD, PAGE 66.]

THOMAS A. EDISON, OF NEWARK, NEW JERSEY, ASSIGNOR TO HIMSELF AND GEORGE HARRINGTON, OF WASHINGTON, DISTRICT OF COLUMBIA.

IMPROVEMENT IN RELAY-MAGNETS.

Specification forming part of Letters Patent No. 141,777, dated August 12, 1873; application filed March 13, 1873.

To all whom it may concern:

Be it known that I, Thomas A. Edison, of Newark, in the county of Essex and State of New Jersey, have invented an Improvement in Telegraphic Instruments, of which the following is a specification:

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Relay-magnets are employed to a large extent in various telegraphic operations. It is, however, found that the adjustment of the springs that draw back the armature and the burning of the contact-points by the spark are sources of constant annoyance.

My present invention is made for preventing the points burning out, and for avoiding adjustment of the retractile armature-springs.

I make use of metallic contact-points within a liquid, such as glycerine or water, so that the motion of one contact-point nearer to or farther from the other raises and lowers the electric tension in the telegraph-line, and operates a distant magnet without forming a spark or breaking the circuit.

In the drawing, Figure 1 is a side view of the relay-magnet with the circuit-cup in section, and Fig. 2 is a side view of the distant magnet.

The finger-key *a* is in a circuit from the battery *b*; so also are the coils of the relay-magnet *c*. The armature *d* and its lever *f* are moved by the spring *e* in one direction, and by the magnet *c* in the other. The circuit-cup *g* is made to contain water, glycerine, or other suitable liquid. In the bottom is the screw or point *i*, connected with the circuit-wire *k*, and the movable point or screw *l* passing through the lever *f* is connected with the other circuit-wire *m*, extending to the distant magnet *n*. The battery *r* is in the circuit to the magnet *n*; and it will now be understood that by adjusting the point *l* nearer to or farther from *i* the proportion of current passing to the magnet *n* can be adjusted so that, when the point *l* is moved by the magnet *c* nearest to *i*, the current from *r* will be sufficiently powerful to energize the magnet *n* and draw down its armature *u*; but when the circuit to the magnet *c* is broken at the key *a*, or otherwise, the movement of the point *l* away from *i* will lessen the tension in the circuit *k m* by the resistance of the intervening liquid, and weaken the power of the electro-magnet *n*, so that its spring or weight *t* will draw away its armature.

The movement of the armature *u* may be made operative in effecting any desired telegraphic operation to which it is adapted. I, however, employ the same especially as a sounder, and in that case the battery *r* and circuit *k m* are local.

I am aware that contact-points within a liquid, such as oil or glycer-

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E. GRAY.

Transmitter for Electro-Harmonic Telegraph.

No. 165,728. Patented July 20, 1875.

Fig. 1.

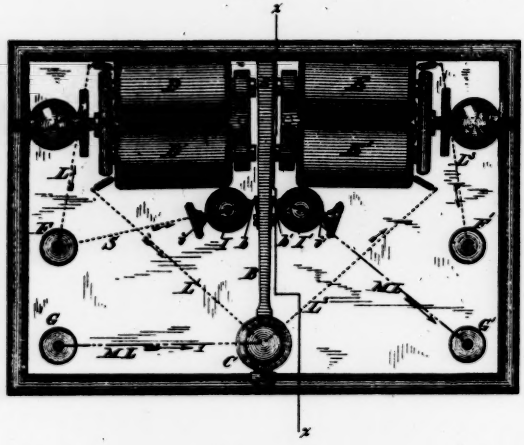
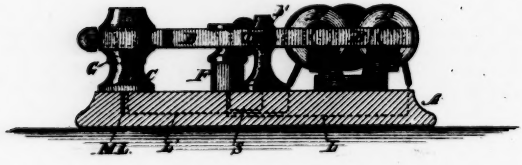


Fig. 2.



WITNESSES

Harry King

E. B. Davidson

Elisha Gray INVENTOR.

By his Attorney

Wm. D. Baldwin

ine, have been employed in the circuit-breaker of an electric engine. In my improvement the circuit is not broken, but the relay-magnet or sounder is operated by rise and fall of tension, and the contact-points are adjustable instead of varying the armature-spring of the magnet.

I claim as my invention

The adjustable contact-points acting within a liquid, in combination with the helix, armature, and spring of a sounder or relay, as set forth.

Signed by me this 7th day of March, A. D. 1873.

THOMAS A. EDISON.

Witnesses:

GEO. T. PINCKNEY,

CHAS. H. SMITH.

DEFENDANT'S EXHIBIT GRAY'S REED TRANSMITTER.

[INTRODUCED RECORD, PAGE 183.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN TRANSMITTERS FOR ELECTRO-HARMONIC TELEGRAPHS.

Specification forming part of Letters Patent No. 165,728, dated July 20, 1875; application filed June 28, 1875.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in transmitters for Electro-Harmonic Telegraphs, of which the following is a specification:

My invention relates to telegraphic apparatus of that class in which a circuit-breaking spring is automatically vibrated with sufficient rapidity to produce a musical tone.

In such instruments as heretofore constructed, so far as my knowledge extends, electro-magnets, by which the spring is attracted, have always been placed on one side of the vibrating bar or electro-tome by which the musical note was produced. A tendency has consequently existed toward the disturbance of its vibrations.

The object of my invention is to remedy this defect; to which end my improvements consist in arranging upon opposite sides of the vibrating spring of the electro-tome, electro-magnets of such relative power as to impart impulses of equal force upon each side of the vibrating spring alternately at equal intervals, thus securing its isochronous vibration. My invention further consists in combining, with the magnets and vibrating spring or reed, shunting wires so arranged as automatically to transfer the current from one magnet to the other without the use of a switch.

In the accompanying drawings, which show so much of my improved apparatus as is necessary to illustrate the subject-matter herein claimed, Figure 1 is a plan or top view; and Fig. 2, a vertical transverse section therethrough, on the line *x x*, Fig. 1.

The apparatus is mounted upon an ordinary base-board, A. A steel-bar spring or vibrating reed, B, tuned to give a musical tone of a given pitch when thrown into vibration is secured by one end to a post, C, while its free end extends between two pairs of magnets, D D′ E E′, arranged transversely to the reeds in the plane of its vibration, their poles being arranged just far enough apart to accommodate this vibratory movement. F F′ G G′ are binding-screws, to which the main and local battery wires are respectively connected. The magnets D D′ are wound with a resistance of about sixteen ohms or units of resistance, while magnets E E′ have only a resistance of about four ohms.

It is a well-known fact that when two magnets of different resistances, other things being equal, are placed in the same circuit and a battery-current sent through them, the magnet having the higher resistance develops the stronger magnetism, which magnetism is stronger in proportion as the resistance is higher than that of the other magnet. In other words, if the magnets E E′, when alone in the circuit, have a power, say, of four, their effect will be diminished to a power of one when magnets D D′ are let in, and the power of the latter will rise from zero to five.

The reed B is provided with spring contact-points *b b′*, arranged one on each side thereof, intermediate between the magnets and its supporting-post. When the reed is at rest these points are in contact with adjusting-screws *i i*, of binding-posts I I′. Fig. 1 shows

the battery connections. The main line M L extends from the binding-screw G through the wire 1 to the reed-supporting post C; thence through the reed and its contact-point b' to the binding-screw I'; thence to the binding-screw G'. The local circuit passes from the battery through the binding-post F by the wire L to the magnets D D'; thence by the wire L^1 through the reed-supporting post C, and the wire L^2 to the magnets E E'; thence by the wire L^3 to the binding-post F'. In addition to this a shunt-wire S, passes from the binding-post F to the post I, through the contact-point b to the reed and its supporting-post C, where it connects with the local circuit L L^2.

The operation of the apparatus is as follows: When the local circuit is established the current does not pass through the magnets D D' by the wire L, as it finds an easier passage through the shunt-wire S and contact-point b, vibrating reed B, post C, and wire L^2 to the magnets E E'; thence by the wire L^3 to the other pole of the local battery. The passage of this current develops in the latter magnet the power, say, of four, which is exerted upon the vibrating reed B, and draws it toward the poles of the magnets. When the reed is moved a short distance in obedience to this impulse its movement causes the contact-point b to separate from the binding-screw i, when of course the current will no longer flow through the shunt-wire S, but passes from the post F through the wire L directly to the magnets D D', and from thence through the wires L^1 L^2 to the magnets E E'; thence through the wire L^3 to the post F', which connects with the other pole of the local battery. This raises the power of the magnets D D' from zero to a power of five, while the other magnets drop from four to one. The result is, that the reed vibrates back toward the magnets D D' with the same force that it did toward the other magnets — that is, a power of four each way. When the points b i come in contact again the magnets D D' are cut out of the circuit by the establishment of the current through the shunt-wire S, and their power drops to zero, and the operation above described is repeated. This alternate opening and closing of the circuit takes place with a frequency equal to the rate per second sufficient to produce the fundamental tone of the vibrating reed. The main-line current is interrupted at every vibration of the reed by the separa-

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tion of the contact-points *b' i'*; consequently a series of impulses corresponding in number with the said vibrations will be transmitted to a suitable receiver and reproduced in a tone of corresponding pitch to that of the vibrating reed, as fully explained in sundry applications for Letters Patent of the United States for apparatus for transmitting musical impressions or sounds telegraphically, heretofore filed by me.

The advantages of my improvement are, that the impulses imparted to the vibrating reed being alike on both sides, its center of vibration coincides with the axis of the reed when at rest. The isochronous vibration of the reed is thus preserved in its integrity, and, consequently, that of the electric waves or impulses generated by it, which are transmitted through the main line, which impulses determine those of the receiver, and the vibrating reed is prevented from being thrown out of tune with the receiver by variations in the battery-power, which variations are liable to occur in the ordinary method.

I claim —

1. The combination, substantially as hereinbefore set forth, of the vibrating electro-tome and magnets arranged on opposite sides thereof, of such relative capacity as to impart impulses of equal force at equal intervals upon each side of the vibrating electro-tome alternately, whereby its isochronous vibration is secured.

2. The combination, substantially as hereinbefore set forth, of the vibrating reed, its counterpoise-magnets, a local circuit, and the shunt-wire, whereby the current is automatically changed to each set of magnets.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON,

E. C. DAVIDSON.

3675

E. GRAY.

Receiver for Electro-Harmonic Telegraph.

No. 166,094. Patented July 27, 1875.

Fig 1.

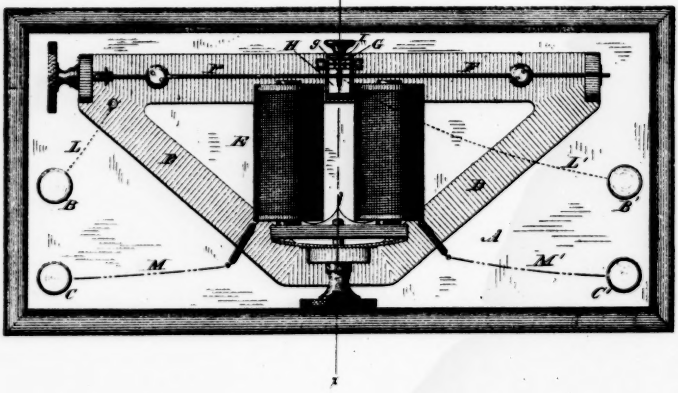
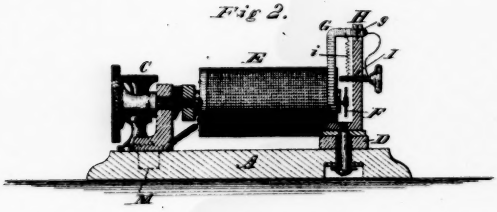


Fig 2.



WITNESSES

Harry King

W. J. Ruffon.

Elisha Gray. INVENTOR

By his Attorney

Wm D. Baldwin

3676

DEFENDANT'S EXHIBIT GRAY'S TUNED BAR RECEIVER PATENT.

[INTRODUCED RECORD, PAGE 67.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN RECEIVERS FOR ELECTRO-HARMONIC TELEGRAPHS.

Specification forming part of Letters Patent No. 166,094, dated July 27, 1875; application filed June 28, 1875.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented a certain new and useful Improvement in Receivers for Electro-Harmonic Telegraphs, of which the following is a specification:

In a previous application for Letters Patent of the United States, filed February 23, 1875, for apparatus for transmitting musical vibrations by electricity, I have shown and described an instrument for receiving musical tones, called an "analyzer," composed of a series of vibrating instruments, each tuned to a different pitch, which receives from the transmitter those tones only which correspond to its own fundamental vibrations when executed by mechanical means. I have also shown in said application a method of making and breaking a local circuit, so as to record Morse or other signals in the ordinary way, the analyzer taking the place of the common Morse relay, the interruptions in the vibrations or signals being made at the sending end by a common telegraphic key. The circuit-interrupter described in my previous application above mentioned consisted of a light metal spring or lever fastened at one end to a post, while its free end rested upon the analyzing-spring or vibrating reed, the contact-point between the two being made of platinum, and the lever having a rate of vibration slower than that of the analyzing-spring or reed which is actuated by electrical impulses from the transmitting end of the line, which synchronize with the natural or fundamental vibration of the analyzing-spring at the receiving end, the tension or rate of vibration of the lever being made adjustable

to a certain extent by a screw provided for that purpose. The local circuit passes through the analyzing-spring and its contact-points to the metal lever, and thence to the instrument and local battery. When the analyzing-spring or reed is thrown into vibration, the metal lever, having a rate of vibration less than that of the analyzing-spring, is not able to follow its vibrations, and thus preserve a continuous contact, as would be the case if its rate of vibration were as great or greater than that of the analyzing-spring, but is made to jar or rattle at the point of contact, and for all practical purposes it opens the local circuit, and holds it open so long as the analyzing-spring continues to vibrate. When the vibration ceases, the points come to rest, and the circuit is re-established, operating a magnet in the ordinary way.

My present invention constitutes an improvement upon the receiver shown in the application above mentioned, and consists in an improved device for operating the local circuit.

In the accompanying drawings, which represent so much of my improved receiving apparatus as is necessary to illustrate the subject-matter herein claimed, Figure 1 is a plan or top view; Fig. 2, a vertical transverse section therethrough on the line *x x* of Fig. 1.

The battery-wires are connected with binding posts or screws B B′ C C′, mounted, as usual, upon a base-board, A. The receiving apparatus is mounted upon a triangular frame, D, of metal, suitably secured to this base by screws or other well-known means. An ordinary electro-magnet, E, is mounted upon this frame, with its poles at right angles to, but in the same horizontal plane as, the vibrating tension-bar or analyzing-spring F, provided with suitable tension devices for regulating the pitch of the tone produced by its vibrations. A light metal elbow-lever or circuit-interrupter, G, rocks on pivots *g* in an insulated post, H, mounted on the metal frame D. The free end of this lever is provided with a platina contact-point, resting on a corresponding point on the vibrating bar, F. The elbow-lever is designed to vibrate at a slower rate than the analyzer spring. This rate of vibration is regulated by a small spiral spring, *i*, one end of which is attached to the elbow-lever, and the other is connected by a cord to a windlass or pins, I, turning in bearings in the post, H. The main current enters the magnet

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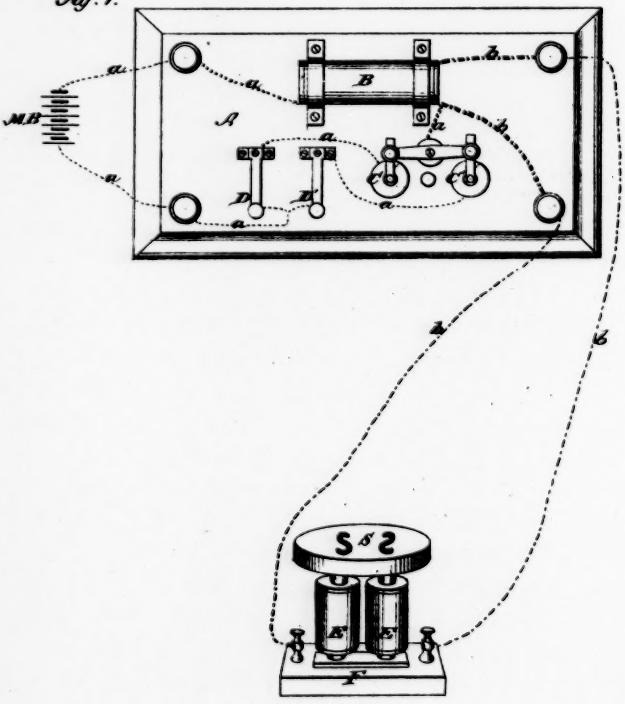
2 Sheets--Sheet 1.

E. GRAY.

Electric Telegraph for Transmitting Musical Tones.

No. 166,095. Patented July 27, 1875.

Fig. 1.



Witnesses.
C. F. Brown.
Everett Hyde

Inventor.
Elisha Gray
by his attorney
A. L. Hayes

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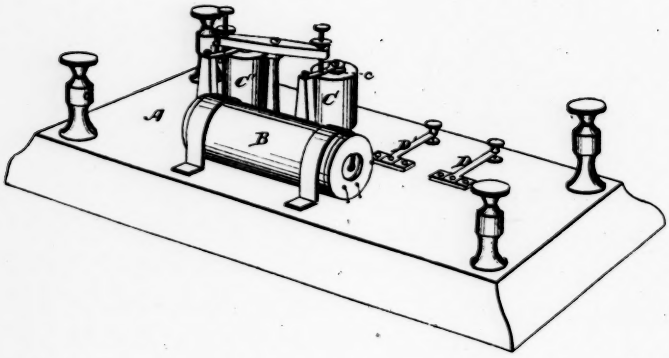
2 Sheets--Sheet 2.

E. GRAY.

Electric Telegraph for Transmitting Musical Tones.

No. 166,095. Patented July 27, 1875.

Fig. 2.



Witnesses.
C. F. Burrus
Ewell A. Hunt

Inventor.
Elisha Gray
by his attorneys
A. L. Hayes & Co.

through the wire, M, and passes out through the wire M′. The local current consists of the wires L L′.

In operation, the impulses transmitted through the main line throw the receiver or analyzing-spring into vibration, and as the elbow-lever G vibrates more slowly, the circuit is practically kept open until closed by the key, as hereinbefore explained.

I claim —

The combination, substantially as hereinbefore set forth, of the vibrating receiving-spring, the elbow-lever circuit-interrupter, and mechanism, substantially such as described, for adjusting the rate of vibration of said lever.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON,
E. C. DAVIDSON.

DEFENDANT'S EXHIBIT GRAY MAGNET RECEIVER PATENT.

[INTRODUCED RECORD, PGAE 67.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN ELECTRIC TELEGRAPHS FOR TRANSMITTING MUSICAL TONES.

Specification forming part of Letters Patent, No. 166,095, dated July 27, 1875; application filed January 19, 1875.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Apparatus for Transmitting Musical Impressions or Sounds Telegraphically, of which I hereby declare the following to be a full, clear, and exact description:

My invention relates to what I term an "electro-harmonic telegraph," and is based upon the fact well known to electricians that an electro-magnet elongates under the action of the electric current,

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and contracts again when the current ceases. Consequently a succession of impulses or interruptions will cause the magnate to vibrate, and if these vibrations be of sufficient frequency a musical tone will be produced, the pitch of which will depend upon the rapidity of the vibrations.

I have discovered that by interrupting an electric current at the transmitting end of a line with sufficient frequency to produce a musical tone by an instrument vibrated by said interruptions, and transmitting the impulses thus induced to an electro-magnet at the receiving end of the line, the latter will vibrate synchronously with the transmitting-instrument, and thus produce a musical tone or note of a corresponding pitch. The object of my invention is to utilize this discovery for the transmission of intelligible signals to a distance by electricity; to which end my improvement consists in the combination of a telegraphic circuit, a series of circuit-breakers capable of producing musical tones of different pitch, a series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation, and an electro-magnet receiver, which is thrown into operation by the transmitter, whereby tones of different pitch may be reproduced at the receiving end of the line by the use of a single circuit.

In the accompanying drawings, Figure 1 shows a plan view of the transmitting part of my improved apparatus, the receiver appearing in perspective. Fig. 2 is a view, in perspective, of the transmitter.

The tran-mitting apparatus is mounted upon a base-board, A, as usual. The induction-coil B has the usual primary and secondary circuits. An ordinary automatic electrotome, C, has a circuit-closing spring, *c*, so adjusted as, when in action, to produce a mu-ical tone according to its length, thickness, and adjustment. A common telegraph-key, D, is placed in the primary circuit to make or break the battery-connection. In the drawings I have shown two electrotomes of identical construction, but of different pitch, and two keys, both the keys and electrotomes being placed in the primary circuit, which is so divided that part of the circuit passes through each key and its corresponding electrotome. The number of electrotomes may be increased, so that tones extending through two or more octaves may

be produced. An ordinary electro-magnet is provided at the receiving end of the line.

The operation of the apparatus is as follows: In the arrangement shown in the drawings when a key is closed the primary circuit will pass from the battery H through that key and its corresponding electrotome, and will be automatically interrupted in the usual manner. The spring of the electrotome will thus be caused to vibrate rapidly and to produce a tone, the pitch of which is determined by the rate of vibration. It is obvious that several keys may be depressed simultaneously. These vibrations or interruptions of the current will simultaneously produce in the secondary circuit of the induction-coil a series of induced currents or impulses corresponding in number with the vibrations of the electrotome, and as the receiving electro-magnet is connected with this circuit it will be caused to vibrate, thus producing a tone of corresponding pitch, the sound of which may be intensified by the use of a hollow cylinder, S, of metal, placed on the poles of the magnet.

When a single electrotrome is thrown into action, its corresponding tone will be reproduced on the sounder by the magnet. When electrotomes of different pitch are successively operated, their tones will be correspondingly reproduced by the receiver, and when two or more electrotomes are simultaneously sounded, the tone of each will still be reproduced without confusion on the sounder, by which means I am enabled to reproduce melodies or tunes.

Mechanical circuit-breakers might be substituted for the automatic vibrating electrotome, hereinbefore described, and I have, in fact, used such mechanical circuit-breakers of various construction; but I found the electrotome more satisfactory in practice.

In this instance the receiver is shown and described as operated by the induced current of the secondary coil; but the secondary or extra current of a primary coil may be used instead thereof with good effect.

My apparatus is specially adapted to telegraphing on long land and submarine lines. By it letters and signals can be represented by tones differing in pitch; or the ordinary Morse signals can be made by short and long interruptions in a prolonged tone of the same pitch, thus securing great rapidity of transmission.

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An application for Letters Patent of the United States, filed by me April 18, 1874, shows an apparatus somewhat similar to the one herein described, for transmitting musical tones through animal tissue to a resonant electrical receiver. I do not, therefore, claim herein anything therein shown. Neither do I claim herein the combination, with a main line, of an intermittent circuit-breaker, or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each such circuit-breaker, as it constitutes the subject-matter of another application filed by me February 23, 1875. The combination of a telegraphic circuit, an automatic circuit-breaker capable of producing a musical tone, and an electro-magnet receiver which reproduces the tone by being thrown into vibration by impulses generated by the circuit-breaker, is not broadly claimed herein, as this combination constitutes a part of the subject-matter of said application, also.

I claim as my own invention —

The combination of a telegraphic circuit, a series of circuit-breakers capable of producing musical tones of different pitch, a series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation, and an electro-magnet receiver, which is thrown into operation by the transmitters, whereby tones of different pitch may be reproduced at the receiving end of the line by the employment of a single circuit.

ELISHA GRAY.

Witnesses:

E. C. DAVIDSON,

WM. J. PEYTON.

DEFENDANT'S EXHIBIT "MAGNET RECEIVER APPLICATION."

[INTRODUCED RECORD, PAGE 110.]

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE.

To all Persons to whom these Presents shall come, GREETING:

This is to certify that the annexed is a true copy from the files of this office of the file wrapper, contents and drawing in the matter of letters-patent granted Elisha Gray. Dated July 27th, 1875. No. 166,095. For Apparatus for Transmitting Musical Tones by Electricity.

In testimony whereof, I, W. H. Doolittle, Acting Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this thirty-first day of March, in the year of our Lord one thousand eight hundred and seventy-seven, and of the Independence of the United States the one hundred and first.

[SEAL]

W. H. DOOLITTLE,
Acting Commissioner.

1. [ORIGINAL APPLICATION.]

To the Commissioner of Patents:

Your petitioner, Elisha Gray, of Chicago, County of Cook, Illinois, prays that letters-patent may be granted to him for the invention set forth in the annexed specification; and he hereby appoints Alexander L. Hayes, of Boston, Mass., as his attorney, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.

ELISHA GRAY.

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To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook, State of Illinois, have invented a new and useful improvement, in Apparatus for Transmitting Musical Tones by Electricity, of which the following is a full, clear, and exact description thereof, which will enable others skilled in the art to which the invention appertains to construct and use the same, reference being had to the drawings accompanying and forming part of this specification:

In the drawings, Fig. 1, sheet 1, is a view showing the transmitting apparatus with its connections in plan, and the receiving apparatus in elevation, and Fig. 1, sheet 2, is a view showing the transmitting apparatus in perspective.

This invention is based upon the observed fact well known to electricians, that when *a coil of wire surrounding a bar of iron or the core of an electro-magnet is traversed* by an electric current, the said bar will be slightly elongated, and if these currents succeed each other with sufficient rapidity, a vibratory motion will be given to said bar, and it will give forth a musical tone.

Erase and insert per Am'd't A, Feb. 3, 1875.

On this principle, an apparatus known as the *telephone*, has been devised, in which the succession of electrical impulses is caused by contacts made by a diaphragm which is thrown into vibration by musical tones produced by the *human voice* or otherwise in near proximity to said diaphragm, but the apparatus does not always operate with certainty and is liable to become disarranged.

My invention consists in using the secondary currents from an induction apparatus or the secondary or extra current from a primary coil for exciting *the coil surrounding the bar of iron*, and in causing the succession of said impulses of the induced current by means of a circuit-breaker which breaks the circuit with the desired rapidity.

An apparatus which I use is constructed as follows, reference being had to the accompanying drawings:

A, is the frame or base of the apparatus at the transmitting end. B, is an induction coil of the usual construction, having the usual primary and secondary circuits. C C,′ are automatic vibrating electrotomes of the usual construction, which, when in action, produce musical *tones* by the vibration of their circuit-breaking springs.

These springs are different in size and adjustment, so that they vibrate at different rates, and each electro[to]me therefore affords a tone of a different pitch. A series of electrotomes may be provided which will give *tones* extending through one or more octaves. D D′, are telegraph keys of the usual construction which are placed in the primary circuit, the said primary circuit being so divided that a part of the circuit passes through each key and its corresponding electrotome.

The keys are used for making connection with the battery.

When a key is closed, the primary circuit will pass from the battery through one [of] the electrotomes C C,′ by the connection, and the circuit will be automatically broken and closed by the spring of the electrotome corresponding to the key depressed in the manner well known.

The spring will therefore vibrate rapidly, and will produce an *audible tone* of a pitch determined by its rate of vibration, and at the same time a series of induced currents corresponding in number to the number of *audible vibrations* in the tone produced will be induced in the secondary circuit of the induction coil B.

Erase and insert per Am'd't A, Feb. 3, 1875.

This circuit may be of any desired length. At the receiving station in said circuit is placed an *electro-magnet* E, *or a coil of wire surrounding a bar of iron.* The succession of currents transmitted from the induction coil will cause the vibration of the *core of the electro-magnet*, or *of the bar of iron as before explained*, and it will give forth a musical tone of the same pitch as that produced by the vibrating circuit-closer. *S, is a hollow box of metal which is placed upon the poles of the magnet, and intensifies the tone produced by the same.*

It is obvious that by having a series of electrotomes whose vibrating springs give tones of a different pitch, which are properly timed, that the electro-magnet can be made to give forth a succession of tones constituting a melody, and by having a series of circuits and a series of circuit-closers and magnets, *a musical composition of a complicated character can be reproduced at a distance* from where it is played, or the different parts of a musical composition can be played in different places and be heard in one place simultaneously.

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The induced currents being of high tension can be transmitted through considerable resistance, and is much more effective for magnetizing the magnet than the primary current.

The apparatus can be worked on long circuits with but slight battery power at the transmitting station.

Instead of an automatic electrotome, for breaking the circuit, mechanical circuit-closers can be used for producing the succession of currents in the induction coil, and instead of using a secondary coil, the extra or secondary current induced in a primary coil may be used.

This apparatus may be used for various purposes.

Erase and insert per Am'd't A, Feb. 3, 1875.

For telegraphing letters and signals may be represented by tones of different pitch, which will be readily recognized by an expert operator, and said signals can be made to succeed each other with great rapidity. The Morse alphabet may be transmitted by interruptions of the proper length in a prolonged tone of the same pitch.

The apparatus can be used on long land lines or on submarine cables.

What I claim as my invention, and desire to secure by letters-patent of the United States, is:

First. The method substantially as described of *producing musical tones* by causing the *vibration of a bar of iron* by transmitting a series *of induced currents through a coil surrounding said bar.*

Second. The combination of an apparatus producing induced secondary currents, with a series of electrotomes or other circuit-breakers, and an electro-magnet arranged in said secondary circuit, substantially as and for the purpose set forth.

In testimony whereof I have hereunto signed my name, this twentieth day of June, A. D. 1874.

ELISHA GRAY.

Witnesses:

EWELL A. DICK,

HENRY R. ELLIOTT.

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CITY OF WASHINGTON,
DISTRICT OF COLUMBIA. }

Elisha Gray, the above-named petitioner, being duly sworn, deposes and says, that he verily believes himself to be the original and first inventor of the improvements in apparatus for transmitting musical tones by electricity, described and claimed in the foregoing specification; that he does not know and does not believe that the same was ever before known or used; and that he is a citizen of the United States.

ELISHA GRAY.

Sworn to and subscribed before me this twentieth day of June, A. D. 1874.

HENRY R. ELLIOTT,
U. S. Com. for the Dist. of Col.

NOTARIAL SEAL.

PATENT OFFICE,
JUNE 27, 1874,
U. S. A.

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3. MOTION TO RE-OPEN.

In re-applications of Elisha Gray, Appl's for Transmitting Musical Tones by Telegraph referred with endorsements to the Hon. Commissioner.

H. C. TOWNSEND,
Ass't. Ex'r. in Ch'g.

220 KINZIE STREET, CHICAGO, Jan. 9, 1875.

The Honorable the Commissioner of Patents:

SIR: The two applications filed by Elisha Gray, in June last, for Letters Patent for an Improved Method of Transmitting Musical Tones by Electricity, and which were ordered to issue July 12, require amendment before the patents are issued, but, for various reasons, Mr. Gray has not been able to make these amendments up to this time, though he intends to do so in a few days.

I have therefore to request that the said applications be not for-

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feited by reason of the non-payment of the balance fees on Jan. 12, six months from July 12, but that they be returned to the examiner for action upon the amendments, which I propose to present.

Respectfully,

ALEX. L. HAYES,

Attorney for ELISHA GRAY.

PATENT OFFICE,
JAN. 12, 1875.
U. S. A.

WASHINGTON, Jan. 12, 1875.

The Hon. the Commissioner of Patents:

SIR: In April and June last Elisha Gray, of Chicago, filed two applications for Letters Patent for a "Method of Transmitting Musical Tones by Electricity," which applications after due examination, were passed for issue July 11, 1874; the balance fees on the same being due Jan. 11, 1875.

After the allowance of these applications it was found that the specifications did not adequately describe the inventions, and that amendments to the same were required, which, for various reasons, the inventor was unable to prepare up to Jan. 9, at which date I intended to leave Chicago, so as to reach Washington on the 11th, and file the amendments before the forfeiture of the applications.

I was unable to leave until the 10th inst., and, therefore, on the 9th, addressed a letter to the Patent Office notifying of my intention to amend, and requesting that the applications be returned to the examiner, and relying upon this letter reaching the Patent Office on the 11th, in due course of mail.

This letter was, however, not received until this morning, so that the applications were duly forfeited yesterday.

I have now to request that this delay in the mails, which was not the fault of the applicant, shall not cause the forfeiture of his applications, but that his notification of his intention to amend be considered as if received on the 11th inst., and that the applications be returned to the Examiner

Respectfully,

ALEX. L. HAYES,

Attorney for

ELISHA GRAY.

Leaving out of consideration the question as to whether a mere modification of intention to amend would justify the Examiner in withdrawing a case from the issue, in order to save it from forfeiture, it would seem that if the analogous case of Henry H. Blake, (Commissioner's Decisions for 1873, page 6,) may be taken as a guide, the present applications must be held to be forfeited. The matter is, however, respectfully referred to the Commissioner.

H. C. TOWNSEND,
Ass't. Ex'r. in Ch'g.

PATENT OFFICE,
JAN. 12, 1875,
U. S. A.

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4. COMMISSIONER'S DECISION.

Recorded Vol. 15, p. 358.

In the matter of the applications of Elisha Gray, filed respectively April 18th and June 27th, 1874, "Apparatus for Transmitting Sound."

MOTION.

The two applications were ordered to issue July 10th, 1874. The six months' limit within which the final fees should have been paid, expired January 10th, 1875.

Applicant moves January 12th, 1875, that the applications be returned to the Examiner for amendment, and submits in support thereof a letter sent to the Commissioner, dated Chicago, January 9th, 1875, asking for this action. This letter was not received in the office until January 12th, and as already stated in the case of H. H. Blake, 3, O. G., p. 2, the date of filing in the office of a paper must control action, and not the apparent date of the instrument. In this case it was impossible for the letter to reach the office, in ordinary course of the mails, within the six months.

The applications must be held to be forfeited, under Sec. 35, of the Patent Law. Under this section the Commissioner has no discretion; the fee must be paid within the time, if no action is taken changing the status of the applications before the office.

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The reason for this is evident; the rights of applicants are not finally determined by such forfeiture, but at any time within two years thereafter the applications may be revived, simply by the payment of new fees.

The motion is denied. J. M. THACHER,
Commissioner of Patents.

Jan. 18th, 1875.

RENEWAL OF APPLICATION.

($15. H.) PETITION.

To the Commissioner of Patents:

Your petitioner represents that on June 27th, 1874, he filed an application for letters-patent for a Method of Transmitting Musical Tones by electricity, which application was allowed July 11th, 1874, but that he failed to make payment of the final fee within the time allowed by law. He now makes renewed application for letters-patent for said invention, and prays that the original specification, oath, drawings and model may be used as part of this application.

Respectfully,
ELISHA GRAY,
By his Att'y,
ALEX. L. HAYES.

WASHINGTON, Jan. 19, 1875.

PATENT OFFICE.
JAN. 19, 1875,
U. S. A.

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5. AMENDMENT A AND LETTER.

Feb. 3, 1875.

WASHINGTON, Feb. 2, 1875.

The Hon. the Commissioner of Patents:

SIR: In the matter of the application of Elisha Gray, for letters-patent for an improvement in Apparatus for Transmitting Musical Tones by Electricity, filed June 27th, 1874, I hereby amend by

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cancelling the specification, except the signature of the inventor, and substituting the enclosed.

ELISHA GRAY,
By his Att'y,
ALEX. L. HAYES.

PATENT OFFICE,
FEB. 3, 1875,
U. S. A.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented a new and useful apparatus for Transmitting Musical Vibrations by Electricity, of which the following is a full, clear and exact description, reference being had to the drawings accompanying and forming part of this specification:

This invention is based upon the observed fact in electrical science that when an electric current is made to circulate *in a coil of wire surrounding a bar of iron, as for instance, the core of an electro-magnet, said bar* on becoming a magnet will be slightly elongated by molecular action, and consequently if the currents succeed each other rapidly, the said bar or core will be made to vibrate, and if the rate of vibration exceeds a certain number of times per second, it will give out a musical tone.

Am'd't A, February 3, 1875.

Upon this principle, an apparatus known as the "telephone," has been devised, and is described in Treatise on Electricity, in which a diaphragm, by being thrown into vibration by the production of a musical tone near the same, is made to break and close an electric circuit as many times per second as there are vibrations per second in the tone produced, which interruptions produce a musical tone of corresponding pitch in a[n] iron bar surrounded by coil of wire, at any distance from the diaphragm, on the principle above explained.

Erase and insert per Am'd't B, June 22, 1875.

The apparatus is, however, of delicate construction, and does not always act with certainty.

My apparatus is *an improved telephone*, in which I make use of induced secondary currents from either a primary or secondary coil for affecting the vibrating bar or core of the vibrating electro-magnet, and cause the necessary succession of said currents by interruptions in a primary circuit made by an automatic mechanical circuit-closer.

In the drawings accompanying this specification, Fig. 1, sheet 1, is a view showing the transmitting apparatus and its connections in plan and the receiving apparatus in elevation, and Fig. 1, sheet 2, is a view showing the transmitting apparatus in perspective.

The apparatus is constructed as follows:

A is the frame or base of the apparatus, at the transmitting station, B is an induction coil of the usual construction, having the usual primary and secondary circuits. C C′ are automatic vibrating electrotomes of the usual construction in which the vibrating circuit-closing springs are so adjusted that when in action they produce musical tones, which from the difference in adjustment, and in the length and thickness of the springs are of different pitch. The number of these electrotomes may be increased so that tones extending through two or more octaves may be produced.

Am'd't A, February 3, 1875.

D D are telegraph keys of the usual form, which are placed in the said primary circuit, and the primary circuit is so divided that a part of the circuit passes through each key and its corresponding electrotome.

Erase and insert per Am'd't B, June 22, 1875.

These keys make and break the battery connection.

The operation is as follows:

When a key is closed the primary circuit will pass from the battery through one of the electrotomes C or C′, and its connections corresponding to the key depres-ed, and the primary circuit will be automatically interrupted in the usual manner.

The spring will therefore be thrown into rapid vibration as long as the circuit is closed at the key, and an *audible tone* of a pitch determined by the rate of vibration of the spring will be produced, while at the same time a series of induced currents corresponding in number to the number of audible vibrations in the tone will be induced in the secondary circuit of the induction coil B.

This circuit may be extended to any distance from the transmitting station. At the receiving station in said circuit is *placed an electro-magnet E, or a coil of wire surrounding a bar of iron*, and said bar or electro-magnet will vibrate as many times per second as there are interruptions in the current, and consequently will give forth a musical tone of the same pitch as that given by the circuit-closing spring as before explained.

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S is a hollow cylinder of metal, which is placed on the poles of the magnet, and intensifies the sound produced by the same.

It is obvious that if a series of electrotomes is provided connected as before stated, each of whose springs gives tones of different pitch that the electro-magnet can be made to give forth corresponding tones by depressing the key and closing the circuit through the electrotome which gives any particular note, and this way the melody which can be produced by means of the electrotomes at the transmitting station can be reproduced on the electro-magnet at the receiving station.

By having a series of electrotomes or circuit-breakers with their corresponding induction apparatus and a series of receiving magnets connected in independent circuits, a musical composition containing chords can be transmitted, or the different parts of a composition, played simultaneously at different places, can be reproduced at one place, or by means of switches, the same or different parts of a composition can be played at different places at a distance from each other in turn.

Am'd't A, February 3, 1875.

Many other remarkable effects may be produced.

The advantage of using induced currents is, that they can be transmitted through considerable resistance owing to their high tension, and also, that they are more effective for magnetizing the electro-magnet, thereby enabling the apparatus to be operated with but small battery power.

Erase and insert per Am'd't B, June 22, 1875.

Mechanical circuit-closers may be used for making the necessary interruptions in the primary circuit of the induction apparatus, and instead of using the secondary current of the secondary coil, the secondary or extra current of a primary coil may be used.

The apparatus can be used for telegraphing on long land or submarine lines.

When used for telegraphing, letters and signals can be represented by tones differing in pitch, or Morse signals can be made by short and long interruptions in a prolonged tone of the same pitch.

What I claim as my invention, and desire to secure by letters-patent is:

First. The method substantially as described of *producing musical tones* by the vibration of *a bar of iron surrounded by a*

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coil of wire or an electro-magnet, by transmitting a series of induced currents corresponding in number per second to the number of audible vibrations per second in the tone produced through said coil or electro-magnet.

Am'd't A, February 3, 1875.

Second. The combination of an apparatus producing induced secondary currents with a series of electrotomes or other circuit-breakers, and an electro-magnet or series of electro-magnets arranged in said secondary circuit, substantially as and for the purpose set forth.

Erase and insert per Am'd't B, June 22, 1875.

PATENT OFFICE,
FEB. 3, 1875,
U. S. A.

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6. ASSOCIATE TO HILL & ELLSWORTH.

WASHINGTON, D. C., March 16, 1875.

To the Commissioner of Patents:

SIR: I hereby authorize Hill & Ellsworth to examine any papers, &c., filed with the applications of Elisha Gray for Telephone.

ALEX. L. HAYES,
Attorney for
E. GRAY.

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7. REJECTION.

March 29, 1875.

No. 1. 67-46-1.

Copy sent March 29.

I. R. A.

Send to HILL & ELLSWORTH,
EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., March 29th, 1875.

E. GRAY, care A. L. Hayes, Boston, Mass.

Apparatus for transmitting Musical Tones by Electricity, filed June 27th, 1874, renewed January 19th, 1875.

Applicant's attention is called to the words "*or series of electro-magnets*" in second claim. These are substantially new matter not in claims originally allowed, and not based on anything in the speci-

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fication. In fact, the main difference between this and applicant's later case, is, that in this one main circuit and *one receiver responding to all notes is used*, in the later one, in one main circuit several receivers, each responding to one note only are used. The words quoted obliterate this distinction. With these words in the claim it is rejected.

Applicant's attention is called to the paragraph concerning Mechanical circuit-breakers, on p. 7 of specification, and to the remarks on the subject, in letter of this date in first case. Another app't shows, describes and claims what is therein suggested.

Z. WILBER, *Ex'r.*

POWER OF ATTORNEY.

ELISHA GRAY, TRANSMITTING MUSICAL TONES BY ELECTRICITY.

Filed June 27, 1874.

Case 2.

(FORM NO. 6. POWER OF ATTORNEY.)

In the United States Patent Office.

In the matter of the application of Elisha Gray, of Chicago, Illinois, for Letters-Patent of the United States, for Apparatus for Transmitting Musical Tones by Electricity, filed June 27, 1874.

WASHINGTON, June 11, 1875.

To the Commissioner of Patents:

The undersigned hereby makes, constitutes and appoints William D. Baldwin, of Washington City, in the District of Columbia, his attorney, with full power and authority of substitution and revocation to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business connected therewith in the Patent Office; and hereby revokes any and all powers of attorney heretofore given

Applicant sign: ELISHA GRAY.

I concur in the above

Assignees sign: SAMUEL S. WHITE.

PATENT OFFICE
JUNE 12, 1875,
U. S. A.

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8. AMENDMENT B AND LETTER.

June 22, 1875.

In the United States Patent Office.

In the matter of the application of Elisha Gray, for Letters-Patent for Apparatus for Transmitting Musical Tones by Electricity, filed June 27th, 1874.

WASHINGTON, D. C., June 22, 1875.

To the Commissioner of Patents:

SIR: In view of official suggestions, an amended specification is herewith filed in the above-mentioned application, without waiving applicant's rights in the premises. Applications will hereafter be filed claiming the Multiple Transmitter; the Mechanical Circuit-Breaker; and the Organ-Pipe Circuit Interrupter.

Respectfully yours,

ELISHA GRAY.

By his Att'y,

WM. D. BALDWIN.

PATENT OFFICE,
JUNE 22, 1875.
U. S. A.

Case 2.

(FORM NO. 2.—AMENDMENT.)

In the United States Patent Office.

In the matter of the application of Elisha Gray for Letters-Patent for Apparatus for Transmitting Musical Tones by Electricity, filed June 27, 1874.

WASHINGTON, D. C., June 21, 1875.

To the Commissioner of Patents:

SIR: Amend the above-mentioned application as follows: Substitute for the specification heretofore filed the following:

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To all whom it may concern:

Am'd't B, June 22, 1875.

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Apparatus for Transmitting Musical Impressions or Sounds Telegraphically, of which I hereby declare the following to be a full, clear and exact description.

My invention relates to what I term an "electro-harmonic" telegraph, and is based upon the fact well known to electricians, that an electro-magnet elongates under the action of the electric current and contracts again when the current ceases, consequently a succession of impulses or interruptions will cause the magnet to vibrate; and if these vibrations be of sufficient frequency, a musical tone will be produced, the pitch of which will depend upon the rapidity of the vibrations.

I have discovered that by interrupting an electric current at the transmitting end of a line with sufficient frequency to produce a musical tone by an instrument vibrated by said interruptions, and transmitting the impulses thus induced to an electro-magnet at the receiving end of the line, the latter will vibrate synchronously with the transmitting instrument, and thus produce a musical tone or note of a corresponding pitch.

The object of my invention is to utilize this discovery for the transmis-ion of intelligible signals to a distance by electricity; to which end my improvement consists in

Am'd't B, June 22, 1875.

Erase per Am'd't E, July 27, 1875.

the combination of a telegraphic circuit, an automatic circuit-breaker capable of producing a musical tone; and an electro-magnet receiver, which reproduces the tone by being thrown into vibration by impulses generated by the circuit-breaker. My improvement further consists of the combination of a telegraphic circuit; a series of circuit-breakers capable of producing musical notes of different pitch; a series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation; and an electro-magnet receiver, which is thrown into operation by the transmitter; whereby tones of different pitch may be reproduced at the receiving end of the line by the use of a single circuit.

In the accompanying drawings, figure 1 shows a plan view of

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the transmitting part of my improved apparatus, the receiver appearing in perspective. Figure 2 is a view in perspective of the transmitter.

The transmitting apparatus is mounted upon a base-board A, as usual. The induction coil B, has the usual primary and secondary circuits. An ordinary automatic electrotome C, has a circuit-closing spring *c* so adjusted as when in action to produce a musical tone according to its length, thickness and adjustment. A common telegraph key D, is placed in the primary circuit to make or break the battery connection.

In the drawings I have shown two electrotomes of identical construction, but of different pitch, and two keys; both the keys and the electrotomes being placed in the primary circuit, which is so divided that part of the circuit passes through each key and its corresponding electrotome. The number of electrotomes may be increased so that tones extending through two or more octaves may be produced. An ordinary electro-magnet is provided at the receiving end of the line.

The operation of the apparatus is as follows:

In the arrangement shown in the drawings, when a key is closed, the primary circuit will pass from the battery H through that key and its corresponding electrotome, and will be automatically interrupted in the usual manner. The spring of the electrotome will thus be caused to vibrate rapidly and to produce a tone, the pitch of which is determined by the rate of vibration. It is obvious that several keys may be depressed simultaneously. These vibrations or interruptions of the current will simultaneously produce, in the secondary circuit of the induction coil, a series of induced currents or impulses corresponding in number with the vibrations of the electrotome; and, as the receiving electro-magnet is connected with this circuit, it will be caused to vibrate, thus producing a tone of corresponding pitch, the sound of which may be intensified by the use of a hollow cylinder S, of metal, placed on the poles of the magnet.

Am'd't B, June 22, 1875.

When a single electrotome is thrown into action, its corresponding tone will be reproduced on the sounder by the magnet. When electrotomes of different pitch are successively operated their tones

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will be correspondingly reproduced by the receiver; and when two or more electrotomes are simultaneously sounded, the tone of each will still be reproduced without confusion on the sounder, by which means I am enabled to reproduce melodies or tunes.

Mechanical circuit-breakers might be substituted for the automatic vibrating electrotome hereinbefore described, and I have in fact used such mechanical circuit-breakers of various construction, but I found the electrotome more satisfactory in practice.

In this instance the receiver is shown and described as operated by the induced current of the secondary coil; but the secondary or extra current of a primary coil may be used instead thereof with good effect.

My apparatus is specially adapted to telegraphing on long land and sub-marine lines. By it, letters and signals can be represented by tones differing in pitch, or the ordinary Morse signals can be made by short and long interruptions in a prolonged tone of the same pitch; thus securing great rapidity of transmission.

An application for letters-patent of the United States, filed by me, April 18th, 1874, shows an apparatus somewhat similar to the one herein described for transmitting musical tones through animal tissue to a resonant electrical receiver; I do not therefore claim herein anything therein shown.*

I claim as my own invention:

The improved apparatus for transmitting musical impressions or sounds telegraphically, hereinbefore set forth, consisting of the combination of a telegraphic circuit, an automatic circuit-breaker capable of producing a musical tone, and an electro-magnet receiver which reproduces the tone by vibrations caused by impulses generated by the circuit-breaker, substantially as described.

[I also claim †] the combination of a telegraphic circuit, a series of circuit-breakers capable of producing musical tones of different pitch, a series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation, and an electro-magnet receiver, which is thrown into operation by the transmitters; whereby tones of different pitch may [simultaneously or successively‡]

* Insert per Am'd't C, July 20, 1875.

Am'd't B, June 22, 1875.

Erase per Am'd't G, July 24, 1875.

† Erase per Am'd't H, July 24, 1875.

‡ Erase per Am'd't D, July 20, 1875.

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be reproduced at the receiving end of the line by the employment of a single circuit.

ELISHA GRAY.

Witnesses:
E. C. DAVIDSON,
WM. J. PEYTON.

DISTRICT OF COLUMBIA, } *ss:*

Elisha Gray, whose application for letters-patent for Apparatus for Transmitting Musical Tones by Electricity was filed in the United States Patent Office, on or about the 27th day of June, 1874, being duly sworn, deposes and says, that in addition to the claims originally made, he verily believes himself to be the original and first inventor of the improvement as described and claimed in the foregoing amendment, and that he does not know, and does not believe that the same was ever before known or used.

ELISHA GRAY.

Sworn to and subscribed before me, }
this 21st day of June, 1875. }

DELOZIER DAVIDSON, *Notary Public.*

NOTARIAL SEAL.

PATENT OFFICE, JUNE 22, 18 5, U. S. A.

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9. OFFICE LETTER.
July 7, 1875.

(No. 1.)
Copy sent July 7th,
I. R. A.

EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., July 7, 1875. }

ELISHA GRAY, care W. D. Baldwin, Present.

TRANSMITTING MUSICAL TONES BY ELECTRICITY.

January 19, 1875.

The 1st claim in this case covers matter interfering with other applications on file.

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The 2d is thought to be clear of interference, covering the combination with several transmitters of *one* receiver. The distinction would be clearer were the words "one electro-magnet receiver thrown into operation by the impulses sent from any of the transmitters" substituted for "an electro-magnet receiver," &c. In the latter part of 2d claim, occurs the words "simultaneously or successively," it is not seen how applicant's single receiver reproduces "simultaneously" several notes or tones.

Upon the subject of a disclaimer, reference is made to letter in other (original case) of even date herewith.

Z. WILBER, *Ex'r.*

---

10. AMENDMENTS C. D.

July 20, 1875.

United States Patent Office.

In the matter of the application of Elisha Gray, for Letters-Patent for Transmitting Musical Tones by Electricity, filed Jan. 19th, 1875. Originally filed June 27th, 1874. (Case 2.)

WASHINGTON, D. C., July 20, 1875

To the Commissioner of Patents:

SIR: Amend the specification of the above-mentioned application as follows:

After page 5, insert the following disclaimer:

"Neither do I claim herein the combination with a main line of an intermittent circuit-breaker or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each such circuit-breaker, as it constitutes the subject matter of another application filed by me, February 23d, 1875." *

Am'd't C, July 25, 1875.

* Insert per Am'd't H, July 25, 1875.

Claim 2, lines 9 and 10 erase, [" simultaneously or successively †"]

† Am'd't D, July 20, 1875.

The above amendments are submitted in view of the official letter

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of July 7th, 1875. The first claim, it will be observed, is for the improved apparatus set forth, and embodies one electro-magnet receiver only, there being no other shown or described.

A re-examination is therefore requested, to determine whether, in view of this fact, applicant is not entitled to the claim without an interference.

Respectfully,

ELISHA GRAY,

By his Att'y,

WM. D. BALDWIN.

PATENT OFFICE.
JULY 20, 1875.
U. S. A.

---

11. AMENDMENTS E, F, G, H.

July 24, 1875.

In the United States Patent Office.

In the matter of Application of Elisha Gray, for Letters-Patent for Transmitting Musical Tones by Electricity, filed Jan. 19th, 1875. Originally filed June 27th, 1874. (Case 2.)

WASHINGTON, D. C., July 24, 1875.

To the Commissioner of Patents:

Amend the specification of the above-mentioned application as follows:

*Am'd't E, July 24, 1875.

[Page 2, cancel lines 17 to 23, both inclusive.*]

Insert immediately before the claim and after the disclaimer of July 20th, 1875, the following:

Am'd't F, July 24, 1875.

"The combination of a telegraphic circuit, an automatic circuit-breaker capable of producing a musical tone, and an electro-magnet receiver, which reproduces the tone by being thrown into vibration by impulses generated by the circuit-breaker, is not broadly claimed herein, as this combination constitutes a part of the subject-matter of said application also."

3704

Page 6, [cancel the 1st clause of claim.†] †Am'd't G, July 24, 1875.

" " line 11, erase ["I also claim."‡] ‡Am'd't H, July 24, 1875.

Very respectfully,

ELISHA GRAY,

By his Att'y,

WM. D. BALDWIN.

PATENT OFFICE,
JULY 24, 1875,
U. S. A.

MEMORANDUM OF FEE PAID AT

U. S. PATENT OFFICE.

INVENTOR,
E. Gray.

Patent to be issued to

INVENTION,
Transmitting Musical Tones by Electricity. (Case 2.)

DATE OF PAYMENT,
July 24th, '75.

SECOND FEE,
$20

SOLICITOR,
Wm. D. Baldwin.

1874.

(50.)

Renewal: WILBER, 67/46

No. 166,095 Div. 16.

ELISHA GRAY.

Of - - Chicago, - - - - -
County of - - Cook - - - - -
State of - - Illinois. - - - -

3705

APPARATUS FOR TRANSMITTING MUSICAL TONES BY ELECTRICITY.

	Rec'd,	June 27th, 1874.	
	"	January 19, 1875.	
	Petition,	June 27, 1874.	
	"	January 19, 1875.	
	Affidavit,	June 27, 1874.	
	Specification,	" " "	
	Drawing 2 sheets,	" " "	
	Model in applicant's pending case.		
	Cert. dep.		
1	Cash $15,	June 27th, 1874.	
	" $15,	January 19th, 1875.	
	Add'l Fee Cert.,		
1	" " Cash $20,	July 24th, 1875.	
	Examined	July 10th, 1874.	Wilber.
	"	July 24th, 1875.	Wilber.
2	Issue,	July 24th, 1875.	Knight.
4	Patented,	July 27th, 1875.	
	Recorded,	vol. page.	
	Circular,	July 11th, 1874.	

W. D. BALDWIN,
Present.

1874.

CONTENTS.

1.	Application,	1 paper.
2.	Passed,	July 10th, '74.
3.	Motion to re-open,	Jan. 12th, '75.
4.	Com'r's Decision,	Jan. 18th, '75.
5.	Admt. A and Letter,	Feb. 3d, '75.
6.	Authorizing H. & E. Asso. Att'y.,	March 6th, 1875.
7.	Rejection,	March 29th, 1875.
8.	Amdt. B and Letter,	June 22d, '75.
9.	Letter,	July 7th, 1875.

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10. Amendments C, D, July 20th, '75.
11. Briefed, July 24th, 1875.
12.
13.
14.
15.
16.
17.
18.
19.
20.

Title:

IMPROVEMENT IN ELECTRIC TELEGRAPHS FOR TRANSMITTING MUSICAL TONES.

"DEFENDANT'S EXHIBIT MAGNET-RECEIVER REISSUE, ART DIVISION."

[INTRODUCED RECORD, PAGE 110.]

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY, OF NEW YORK CITY.

IMPOVEMENT IN ART OF TRANSMITTING MUSICAL IMPRESSIONS OR SOUNDS TELEGRAPHICALLY.

Specification forming part of Letters Patent No. 166,095, dated July 27, 1875; reissue No. 8,558, dated January 28, 1879; application filed May 7, 1878.

DIVISION A.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented certain new and useful Improvements in the Art of Transmitting Musical Impressions or Sounds Telegraphically, of which improvements I hereby declare the following to be a full, clear, and exact description.

My invention relates to what I term an "electro-harmonic tele-

graph," and is based upon the fact, well known to electricians, that an electro-magnet elongates under the action of an electric current, and contracts again when the current ceases; consequently a succession of impulses or interruptions will cause the magnet to vibrate, and if these vibrations be of sufficient frequency a musical tone will be produced, the pitch of which will depend upon the rapidity of the vibrations.

My improvements are based upon the discovery above mentioned.

The subject-matter claimed will hereinafter specifically be designated.

In the accompanying drawings, Figure 1 represents an arrangement upon circuit of apparatus which I use for carrying out the objects of my invention, the transmitting part of the apparatus being shown in plan, and the receiver in perspective. Fig. 2 represents a view in elevation of the transmitting apparatus; Fig. 3, an end view thereof; and Fig. 4, a detail view of one of the rheotomes.

In the apparatus shown I make use of induced currents from either a primary or secondary coil for affecting the vibrating bar or core of an electro-magnet, and cause the necessary succession of said currents by interruption in the primary circuit made by an automatic or mechanical circuit-breaker.

The transmitting apparatus is mounted upon a suitable frame or base, A. An ordinary induction-coil, B, has the usual primary and secondary circuits *a b*. Automatic vibrating electrotomes C C′, of the usual construction, have their vibrating circuit-closing springs C so adjusted that when in action they produce musical tones, which, from the difference in adjustment and the length and thickness of the springs, are of different pitch. A common telegraph-key, D, is placed in the primary circuit to make or break the battery-connections.

In the drawings I have shown two electrotomes of identical construction, but of different pitch and two keys. Both the keys and electrotomes are in the primary circuit, which is so divided that part of the circuit passes through each key and its corresponding electrotome. The number of electrotomes may be increased, so that tones extending through two or more octaves may be produced.

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At the receiving-station an electro-magnet, E, or a coil of wire surrounding a bar of iron, is placed in circuit. A hollow box, drum, cylinder, or resonator, S, of metal, is placed on the poles of the magnet. This resonator it will be observed, is composed of a circumferential band, having two end walls, disks, or diaphragms, one of which rests upon the magnets, constituting an armature therefor, and vibrating in unison therewith, while the other is perforated with S-shaped openings, somewhat like the sounding-board of a violin, thus constituting what I call a "common receiver" — that is, one capable of responding to or reproducing all kinds of tones.

The operation of the apparatus is as follows: Under the arrangement shown in the drawings when the key is closed the primary circuit will pass from the battery M B through the wires *a*, the key, and its corresponding electrotome, and will be automatically interrupted in the usual manner. The spring of the electrotome will thus be caused to vibrate rapidly and to produce a tone, the pitch of which is determined by the rate of vibration.

It is obvious that several keys may be closed or depressed simultaneously.

The rhythmical impulses, vibrations, or interruptions of the current representing the tones will simultaneously produce in a secondary circuit *b*, of the induction-coil, a series of induced currents, impulses, or vibrations, corresponding in number with the vibrations of the electrotomes, and as the receiving electro-magnet E is connected with this current, it will be caused to vibrate correspondingly, thus producing a tone or tones of corresponding pitch with those received from the transmitting apparatus. These tones are audibly reproduced and their sound intensified by the use of the hollow box, cylinder, sound-intensifying chamber, or resonator S, above mentioned.

The circuit may obviously be extended to any distance desired from the transmitting-station.

When a single electrotome is thrown into vibration, its corresponding tone will be reproduced on the sounder or resonator S by the magnet. When electrotomes of different pitch are successively operated, their tones will be correspondingly reproduced by the receiver or resonator; and when two or more electrotomes are simultaneously

sounded, the tone of each will still be reproduced without confusion on the sounder or resonator, by which means I am enabled to reproduce composite tones, melodies, or tunes.

Mechanical circuit-breakers may be substituted for the automatically-vibrating electrotomes hereinbefore described. I have, in fact, used such mechanical circuit-breakers of various construction; but I have found the electrotome more satisfactory in practice.

In this instance the receiver is shown and described as operated by the induced current of the secondary coil; but the secondary or extra current of the primary coil may be used instead thereof with good effect.

The above-described apparatus is especially adapted to telegraph on long land and submarine lines. By it letters and signals can be represented by tones differing in pitch; or the ordinary Morse signals can be made by short and long interruptions in the prolonged tone of the same pitch, thus insuring great rapidity of transmission.

I do not claim herein the apparatus itself, as that forms the subject-matter of another division of this application filed simultaneously herewith.

Letters Patent of the United States No. 166,096, granted to me July 27, 1875, on an application originally filed April 18, 1874, show an apparatus somewhat similar to the one herein described for transmitting musical tones through an electric circuit composed in part of animal tissue, and a resonant metallic receiver, but without the intervention of a magnet. I do not, therefore, claim herein anything shown in said patent. Neither do I claim herein the combination, with a main line, of an intermittent circuit-breaker, or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each of such circuit-breakers, as such combination constitutes the subject-matter of another application for Letters Patent of the United States, filed by me February 23, 1875.

The combination of a telegraphic circuit, an automatic circuit-breaker capable of producing a musical tone, and an electro-magnet receiver for reproducing the tone by being thrown into vibrations by impulses generated by the circuit-breaker is not broadly claimed herein, as this combination constitu'es a part of the subject-matter

of my said application also; but neither of the said applications above mentioned show a disk or diaphragm of metal, or a sound-intensifying chamber or resonator in combination with a magnet.

I claim as of my own invention —

1. The hereinbefore-described novel art, method, or system of audibly and simultaneously reproducing upon the metal disk or diaphragm of the receiver (through the intervention of the electro-magnet included in the electric circuit), two or more series of rhythmical impulses or vibrations representing musical impressions, or sounds, or compo-ite tones.

2. The hereinbefore-described novel art, method, or system of intensifying in the resonator composite tones produced by the conjoint operation of the electro-magnet included in the electric circuit, and the disk or diaphragm of metal vibrating in unison therewith.

3. The hereinbefore-described novel art, method, or system of simultaneously transmitting two or more series of rhythmical impulses or vibrations representing composite tones through the electric circuit, and reproducing them through the intervention of the magnet, and the disk or diaphragm of metal vibrating in unison therewith at the receiving end of the line.

4. The hereinbefore-described novel art, method, or system of simultaneously reproducing in the electric circuit two or more series of rhythmical impulses or vibrations representing musical impressions or sounds, or composite tones, by the conjoint operation of the disk or diaphragm of metal, vibrated in unison with the electro-magnet by induced currents of electricity.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

A. G. SWARTWOUT.

D. M. ERSKINE, Jr.

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"DEFENDANT'S EXHIBIT MAGNET-RECEIVER REISSUE, APPARATUS DIVISION."

[INTRODUCED RECORD, PAGE 110.]

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY, OF NEW YORK CITY.

IMPROVEMENT IN APPARATUS FOR TRANSMITTING MUSICAL IMPRESSIONS OR SOUNDS TELEGRAPHICALLY.

Specification forming part of Letters-Patent No. 166,095, dated July 27, 1875; reissue No. 8,559, dated January 28, 1879; application filed May 7, 1878.

DIVISION B.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Apparatus for Transmitting Musical Impressions or Sounds Telegraphically, of which I hereby declare the following to be a full, clear, and exact description.

My invention relates to what I term an "electro-harmonic telegraph," and is based upon the fact, well known to electricians, that an electro-magnet elongates under the action of an electric current, and contracts again when the current ceases; consequently a succession of impulses or interruptions will cause the magnet to vibrate, and if these vibrations be of sufficient frequency a musical tone will be produced, the pitch of which will depend upon the rapidity of the vibrations.

The object of my present invention is to utilize this discovery for the transmission of intelligible signals to a distance by electricity, which ends I attain, first, by employing a diaphragm or disk of metal, (capable of responding to all kinds of tones,) vibrating in unison with an electro-magnet included in an electric circuit, to reproduce audibly rhythmical impulses or vibrations representing musical impressions or sounds, or tones transmitted through said circuit; second, by employing a sound-intensifying chamber or

resonator, having a disk or diaphragm, responsive to rhythmical impulses or vibrations representing musical impressions or sounds, whereby said rhythmical impulses or vibrations are intensified and rendered audible; third, by combining an electric circuit, a sound-intensifying chamber or resonator, and a metal disk or diaphragm, acted upon through the intervention of an electro-magnet included in the circuit, to intensify and render audible rhythmical impulses or vibrations representing musical impressions or sounds produced in said magnet; fourth, by employing induced currents to reproduce upon a disk or diaphragm of metal (through the intervention of a magnet) rhythmical vibrations representing musical impressions or sounds; fifth, by employing a transmitter consisting of a coil or helix inducing rhythmical electric impulses or vibrations in an electric circuit without interrupting its continuity, and a receiver consisting of an electro-magnet having a metal disk or diaphragm for its armature; sixth, by combining a telegraphic circuit, a series of circuit-breakers capable of producing musical notes of different pitch, a series of keys for throwing said circuit-breakers into or out of operation, and an electro-magnet receiver vibrated by the transmitters.

In the accompanying drawings, Figure 1 represents an arrangement upon circuit of apparatus which I use for carrying out the objects of my invention, the transmitting part of the apparatus being shown in plan and the receiver in perspective; and Fig. 2 represents a view, in elevation, of the transmitting apparatus; Fig. 3, an end view thereof, and Fig. 4 a detail view of one of the rheotomes.

In the apparatus shown I make use of induced currents from either a primary or secondary coil for affecting the vibrating bar or core of an electro-magnet, and cause the necessary succession of said currents by interruption in the primary circuit made by an automatic or mechanical circuit-breaker.

The transmitting apparatus is mounted upon a suitable frame or base, A. An ordinary induction-coil, B, has the usual primary and secondary circuits *a b*. Automatic vibrating electrotomes C C′, of the usual construction, have their vibrating circuit-closing springs *c* so adjusted that when in action they produce musical tones, which, from the difference in adjustment and the length and thickness of the

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springs, are of different pitch. A common telegraph-key, D, is placed in the primary circuit, to make or break the battery-connection.

In the drawings I have shown two electrotomes of identical construction, but of different pitch, and two keys. Both the keys and electrotomes are in the primary circuit, which is so divided that part of the circuit passes through each key and its corresponding electrotome. The number of electrotomes may be increased, so that tones extending through two or more octaves may be produced.

At the receiving-station an electro-magnet, E, is placed in circuit. A hollow box, drum, cylinder, or resonator, S, of metal, is placed on the poles of the magnet. This resonator, it will be observed, is composed of a circumferential band having two end walls, disks, or diaphragms, one of which rests upon the magnets, constituting an armature therefor, and vibrating in unison therewith, while the other is perforated with S-shaped openings, somewhat like the sounding-board of a violin, thus constituting what I call a "common receiver" — that is, one capable of responding to or reproducing tones of all kinds.

The operation of the apparatus is as follows: Under the arrangement shown in the drawings, when a key is closed, the primary circuit will pass from the battery M B through the wires *a*, the key, and its corresponding electrotome, and will be automatically interrupted in the usual manner. The spring of the electrotome will thus be caused to vibrate rapidly, and to produce a tone the pitch of which is determined by the rate of vibration. It is obvious that several keys may be closed or depressed simultaneously. The rhythmical impulses, vibrations, or interruptions of the current representing the tones will simultaneously produce in the secondary circuit, *b*, of the induction-coil a series of induced currents, impulses, or vibrations corresponding in number with the vibrations of the electrotome; and, as the receiving electro-magnet E is connected with this circuit, it will be caused to vibrate correspondingly, thus producing a tone or tones of corresponding pitch with those received from the transmitting apparatus. These tones are audibly reproduced and their sound intensified by the use of the hollow box, cylinder, sound intensifying chamber, or resonator above mentioned. The circuit may

obviously be extended to any distance desired from the transmitting-station.

When a single electrotome is thrown into vibration, its corresponding tone will be reproduced on the sounder or resonator S by the magnet. When electrotomes of different pitch are successively operated, their tones will be correspondingly reproduced by the receiver; and when two or more electrotomes are simultaneously sounded the tone of each will still be reproduced without confusion in the sounder or resonator S, by which means I am enabled to reproduce composite tones, melodies, or tunes.

Mechanical circuit-breakers may be substituted for the automatically-vibrating electrotomes hereinbefore described. I have, in fact, used such mechanical circuit-breakers of various construction; but I have found the electrotome more satisfactory in practice. In this instance the receiver is shown and described as operated by the induced current of the secondary coil; but the secondary or extra current of the primary coil may be used instead thereof with good effect.

The above-described apparatus is especially adapted to telegraph on long land and submarine lines. By it letters and signals can be represented by tones differing in pitch; or the ordinary Morse signals can be made by short and long interruptions in a prolonged tone of the same pitch, thus insuring great rapidity of transmission.

I do not broadly claim herein an art, method, or system of transmitting musical impressions or sounds telegraphically, as that constitutes the subject-matter of another division of this application filed herewith.

Letters Patent of the United States No. 166,096, granted to me July 27, 1875, (on an application originally filed April 18, 1874,) show an apparatus somewhat similar to the one herein described, for transmitting musical tones through an electric circuit composed, in part, of animal-tissue and a resonant metallic receiver, but without the intervention of a magnet. I do not therefore claim herein anything shown in said application. Neither do I claim herein the combination, with a main line, of an intermittent circuit-breaker, or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for,

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and controlling each of, said circuit-breakers, as such combination constitutes the subject-matter of another application for Letters Patent of the United States filed by me February 23, 1875.

The combination of a telegraph-circuit, an automatic circuit-breaker capable of producing a musical tone, and an electro-magnet receiver for reproducing the tone by being thrown into vibrations by impulses generated by the circuit-breaker is not broadly claimed herein, as this combination constitutes a part of the subject-matter of my said application also.

But neither of the said applications above mentioned shows a diaphragm or a sound-intensifying chamber or resonator in combination with a magnet.

I claim as of my own invention—

1. The diaphragm or disk of metal, capable of responding to all kinds of tones, vibrating in unison with the electro-magnet included in the electric circuit, substantially as set forth.

2. The sound-intensifying chamber or resonator, having a disk or diaphragm of metal, responsive to rhythmical impulses or vibrations representing musical impressions or sounds produced in the electric circuit through the intervention of the electro-magnet, substantially as set forth.

3. In combination, the electric circuit, the sound-intensifying chamber or resonator, the diaphragm or disk of metal, and the electro-magnet, the two latter vibrating responsively to rhythmical impulses or vibrations representing musical impressions or sounds transmitted through said circuit, substantially as set forth.

4. In combination, the primary circuit, the secondary circuit, the electro-magnet, and the disk or diaphragm of metal, responsively vibrated by induced currents of electricity to reproduce rhythmical impulses or vibrations representing musical impressions or sounds, substantially as set forth.

5. In combination, the transmitter consisting of a coil or helix, whereby rhythmical electrical impulses or vibrations may be induced in the telegraphic circuit without interrupting the continuity of the same, and the receiver consisting of the electro-magnet, having the metal disk or diaphragm for its armature, these being arranged to vibrate in unison with each other, and with the impulses or vibrations

proceeding from the transmitting or inducing coil, substantially as set forth.

6. In combination, a telegraphic-circuit, a series of circuit-breakers capable of producing musical tones of different pitch, a series of keys for throwing said circuit-breakers into or out of operation, and an electro-magnet receiver which is thrown into vibration by the transmitters, whereby tones of different pitch may be reproduced at the receiving end of the line by the employment of a single circuit, substantially as set forth.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

A. G. SWARTWOUT,
D. M. ERSKINE, Jr.

DEFENDANT'S EXHIBIT, "GRAY'S ANIMAL TISSUE PATENT."

[INTRODUCED RECORD, PAGE. 67.]

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR OF ONE-HALF HIS RIGHT TO SAMUEL S. WHITE, OF PHILADEPHIA, PENNSYLVANIA.

IMPROVEMENT IN ELECTRIC TELEGRAPHS FOR TRANSMITTING MUSICAL TONES.

Specification forming part of Letters Patent, No. 166,096, dated July 27, 1875; application filed January 19, 1875.

CASE 1.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented a new and useful Art of Transmitting Mu-ical Impressions or Sounds Telegraphically, as well as certain new and useful Improvements on Appaiatus for so Transmitting such Impressions or Sounds, of which art and apparatus I hereby declare the following to be a full, clear, and exact description.

My invention relates to a novel art of transmitting musical impres-

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sions or sounds telegraphically, which impressions or sounds may be utilized as signals for the transmission of intelligence.

My invention is based upon the well-known law of acoustics that bodies vibrating with different rapidity produce tones of different pitch, and upon my own discovery that such vibrations can be transmitted through a telegraphic circuit and reproduced in a musical tone or note of a pitch corresponding with that originally transmitted by including in the circuit animal tissue or other equivalent substance, which will cause a slight resistance to the electrical current at the point of contact between such animal tissue and some resonant conductor of electricity.

My improvement consists in a new and useful art of producing musical impressions or sounds at the transmitting end of a telegraphic circuit by causing interruptions in the electric currents of sufficient frequency to produce musical tones, transmitting said tones through an electric circuit composed in part of animal tissue, and reproducing them at the receiving end of the line by means of a resonant body, which is also a conductor of electricity.

My improvement further consists in a new and useful apparatus for carrying out the objects of my invention, which apparatus consists of the combination of a telegraphic circuit composed in part of animal tissue, a circuit-breaker capable of producing a musical tone, and a receiver capable of reproducing that tone at the receiving end of the circuit.

My improvement further consists of the combination, in an apparatus such as described, of a series of circuit-breakers capable of producing musical tones of different pitch, and a series of keys for simultaneously or successively throwing the circuit-breakers into or out of operation, whereby several tones simultaneously or successively may be transmitted through a single wire.

The subject-matter claimed will hereinafter specifically be designated.

In the accompanying drawings, Figure 1 represents a plan or top view of a portion of the transmitting apparatus. Fig. 2 is a front elevation of the same, and Fig. 3 a diagram, showing an arrangement of parts and circuits which advantageously may be employed in working my invention.

The transmitting apparatus is mounted, as usual, upon a base-board, A. An induction-coil, B, is provided with primary and secondary helices of the usual construction. A common vibrating electrotome, C, having its circuit-breaking spring *a* of such length, thickness, and adjustment that its vibration produces a musical tone of a certain pitch, forms part of the circuit.

It is obvious that the apparatus may be worked with a single electrotome, the pitch of which may be varied by adjustment; but where a series of tones of different pitch is desired, I prefer to employ a series of electrotomes having different rates of vibration.

Two electrotomes, C C′, of identical construction, but differing in pitch, are shown in the drawings; but I propose, under some circumstances, to use a series of electrotomes which will give tones extending through one or more octaves. These electrotomes are, by preference, placed in the primary circuit of the induction-coil, and, when in operation, induce secondary currents or impulses in the secondary circuit of said coil equal in number to the vibrations of the circuit-breaking spring of the electrotome.

An ordinary telegraph-key situated in the primary circuit opens or closes the connections of the battery. Each electrotome must have a corresponding key. In the drawings, two keys, D D′, are shown, both of which, as well as the electrotomes, are situated in the primary circuit, which is divided or branched in order to pass through them.

Fig. 3 shows the arrangement of the circuits. The primary circuit F, connected with the battery E, passes through the keys D D′, the magnets of the electrotomes, and the primary circuit of the induction-coil B. One terminal of the secondary circuit G, extends from the induction-coil to the receiving-station through animal tissue to a suitable resonant conductor of electricity, which is, in this case, a hollow metallic cylinder, H, which is connected with the ground. The other terminal, I, of the induction-coil passes directly to the ground in the ordinary way.

The animal tissue interposed between the wire and the resounding receiver to complete the circuit is shown in the drawings as consisting of the body of the receiving-operator, who must be insulated from the ground; but other substances may be employed which must

possess the specific characteristics of being conductors of electricity, — of being yielding and elastic, and of having a surface of greater electric resisting capacity than its interior.

These characteristics are found in the skin of the human body, in leather moistened with acidulated water, in animal flesh covered with a membraneous coating, in bacon-rind, in pork-skin, especially pieces taken from the ear or tail, in kid gloves, and in other substances which need not be enumerated, as they do not operate so perfectly as those above given.

The operation of the apparatus is as follows: The closing of either of the keys completes the primary circuit from the battery through the electrotome connected with the key depressed, and the circuit-closing spring of said electrotome will immediately be thrown into rapid vibration, and a musical tone of a certain pitch dependent upon the length, thickness, and adjustment of the spring will be given forth, while at each vibration the current in the primary circuit of the induction apparatus will be interrupted. These interruptions produce corresponding secondary currents or impulses in the secondary circuit of the induction apparatus, and these secondary induced currents or impulses are transmitted to the receiving-station. Thus, for example, if the circuit-breaking spring of the electrotome vibrates one hundred and twenty-eight times per second, the tone given forth is that known as the "fundamental C," while one hundred and twenty-eight terminal secondary currents or impulses will be induced in the secondary circuit of the induction apparatus, and transmitted through the animal tissue above mentioned, forming part of said circuit, to the resonant receiver, and will, from some cause not understood or explicable in the present stage of the art, vibrate the same synchronously with the transmitting-electrotome, and thus give forth a musical tone of the same pitch.

A metallic plate stretched by metallic strings above a sounding-board — such, for instance as the body of an ordinary violin — may be used with good effect to receive the vibrations, instead of the hollow cylinder above described.

From the foregoing description it will be seen that musical tones produced at the transmitting-station can simultaneously be produced at the receiving-station, however distant. When two or more keys

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are simultaneously or successively depressed, corresponding tones will simultaneously be transmitted, thus producing harmony or melody.

The interruptions in the primary circuit which cause the induced secondary currents or impulses may be produced by a mechanical circuit-breaker having the requisite rapidity of motion, such as a revolving wheel or revolving brush, or they may be produced by providing the vibrating reed or reeds of an organ with contact-points, so that, as the reed vibrates, it will transmit impulses corresponding in number per second to the number of vibrations per second of the notes sounded by the organ pipe.

I prefer to use the impulses of the induced secondary currents as the transmitting medium, as such use affords the most convenient way of obtaining electricity of high tension, which is that best adapted for penetrating a slightly-resisting medium, such as the animal tissue hereinbefore mentioned.

The secondary coil is not essential, as the secondary circuit induced n the primary coil may be utilized for transmitting the signals.

My improvement enables me to operate with a very slight amount of current, as the battery-power required to produce and transmit the vibrations is less than one-hundredth part of the battery-power now required to transmit signals over long land-lines.

My improved method can advantageously be substituted for the Morse telegraph-alphabet now in general use, as an alphabet can be constructed on the principle of using tones of different pitch for the different letters, which will admit of great rapidity of transmission.

By means of my improved apparatus not only may a tune be transmitted by a single operator to a distant point, but the different parts of such tune simultaneously may be reproduced at a common point from different places, a separate part of the tune being played at each place.

The apparatus can also advantageously be employed in studying acoustics and the physical theory of music.

The combination, with a main line, of an intermittent circuit-breaker, or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each such circuit-breaker, are not

broadly claimed herein, as they constitute a part of the subject matter of another application for Letters Patent of the United States, filed by me February 23, 1875.

I claim as my invention, —

1. The hereinbefore-described art of transmitting musical impressions or sounds telegraphically by producing musical impressions or sounds at the transmitting end of a telegraphic circuit by causing interruptions in the electric currents of sufficient frequency to produce musical tones, transmitting said tones through an electric circuit composed in part of animal tissue, and reproducing them at the receiving end of the line by means of a resonant body, which is also a conductor of electricity, substantially set forth.

2. The electro-harmonic telegraph apparatus hereinbefore set forth, consisting of the combination of a telegraph-circuit composed in part of animal tissue, a circuit-breaker capable of producing a musical tone, and a resonant conductor of electricity capable of reproducing that tone at the receiving end of the circuit.

3. The combination, substantially as hereinbefore set forth, of a telegraphic circuit composed in part of animal tissue, a resonant receiver, which is also a conductor of electricity, a series of circuit-breakers capable of producing musical tones of different pitch, and a corresponding series of keys for throwing the circuit-breakers into or out of operation, whereby several tones simultaneously may be transmitted through a single wire.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON,
E. C. DAVIDSON.

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"DEFENDANT'S EXHIBIT ANIMAL TISSUE APPLICATION."

[INTRODUCED RECORD, PAGE 110.]

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these Presents shall Come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the files of this office, of the file wrapper contents and drawing in the matter of the letters-patent, granted Elisha Gray, assignor of ½ his right to Samuel S. White, dated July 27th, 1875, No. 166,096. For improvement in Electric Telegraphs for Transmitting Musical Tones.

In testimony whereof, I, W. H. DOOLITTLE, Acting Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this seventh day of February, in [SEAL] the year of our Lord one thousand eight hundred and seventy-eight, and of the Independence of the United States the one hundred and second.

W. H. DOOLITTLE,
Acting Commissioner.

[1. ORIGINAL APPLICATION.]

PETITION.

To the Commissioner of Patents:

The petition of Elisha Gray, of Chicago, in the County of Cook and State of Illinois, respectfully represents;

That your petitioner has invented a new, useful and improved Electric Apparatus for Transmitting Sound, which he verily believes has not been known or used prior to the invention thereof by your petitioner. He therefore prays that Letters-Patent of the United States of America, may be granted to him therefor, vesting in him and his heirs and assigns the exclusive right to the same, upon the terms and conditions expressed in the act of Congress, in such case

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made and provided; he having paid fifteen dollars into the treasury of the United States, and otherwise complied with the requirements of said act. Your petitioner hereby nominates and appoints Gridley and Warner, of the City of Chicago, State of Illinois, his attorneys, with full power of substitution and revocation to prosecute said application, to make alterations and amendments therein, to sign his name to the drawings, to receive the patent when issued, and to transact all business in the Patent Office connected therewith.

ELISHA GRAY.

OATH.

STATE OF ILLINOIS, } ss.
COUNTY OF COOK, }

Elisha Gray, the above named petitioner, being duly sworn, says that he verily believes himself to be the original and first inventor of the within described improved electric apparatus; that he does not know or believe that the same was ever before known or used; and that he is a citizen of the United States.

ELISHA GRAY.

Subscribed and Sworn to before me, this 13th day of April, 1874.

W. B. HASWELL,
Notary Public.

NOTARIAL SEAL.

SPECIFICATION.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois have invented a new, useful and improved Electric Apparatus for Transmitting Sound, of which the following is a full, clear and exact description which will enable others, skilled in the art to which my invention appertains to make and use the same, reference being had to the accompanying drawing and diagram, forming a part hereof, and in which —

Erase and insert per Am'dt A, June 24, 1874.

Figure 1, sheet 4, is a top view or plan of an electric apparatus for transmitting sound, and in which my improvements are embraced. Figure 2, sheet 1, a front elevation of the same. Sheet

2 is a diagram, showing an arrangement of parts and circuits which may be employed in connection with my improvements. Like letters of reference indicate like parts. —

I am aware that sound has been produced by means of electric force, but this sound, so far as I am aware, has not been strictly transmitted or reproduced heretofore by means of an electric current, but has resulted from the striking together of certain parts of the instrument operated upon, the concussion of one instrument being simultaneous, or nearly so, with that of the other. A monotone has thus been produced at a receiving instrument, and the pitch determined by the parts there brought together. The characters consisting of dots and of dashes varying from each other in length, commonly employed in telegraphy, produces in this sound intermissions varying from each other in duration, and expert operators are thus able to interpret messages by distinguishing the correspondence between the intermissions and the characters.

My object is to transmit sound from one place to another by means of an electric current, in such a manner that the pitch of the sound received may be determined or controlled at its destination, by means employed for that purpose at the place from which the sound is sent, and to that end my invention consists in producing the sound by means of an electric current carried by a circuit consisting in part of living tissue and operating in connection with one or more vibrating pieces arranged to interrupt the circuit by their vibrations, and in connection with a sounding piece for receiving or reproducing the pitch.

Erase and insert per Am'dt A, June 24, 1874.

In the drawing, A represents the base or frame of an apparatus which may be employed for the purposes set forth. B is a common induction coil having the ordinary primary and secondary helices. C is an ordinary vibrating electrotome, which when in action, produces a note of a given pitch, the latter being determined by the number of vibrations of the vibrating piece during any given time and the number of vibrations depending either or the dimensions of the said piece, or on its action when otherwise controlled. C′ is also an electrotome. These electrotomes rae in all respects alike excepting that the dimensions of the vibrating piece of one are such as to produce a sound different in pitch from that produced by the other.

The points resting on the said pieces are adjustable so that the pitch may be thereby varied.

In this manner a number of notes differing from each other in pitch may be produced either by regulating the action of a single vibrator or by employing a number of vibrators each tuned to a different pitch. The vibrating pieces (*a* and *a'*) herein shown are vibrated by means of electro-magnets in the same circuit with the primary helix, in the usual way, and are similar in their construction to the reeds employed to produce musical sounds in wind instruments. These pieces, however, may be vibrated in various ways for the purpose of interrupting the circuit.

D and D' are common telegraphic keys, having the ordinary points of contact. E is the sounding piece, receiver, or reproducer, which may consist of anything which will conduct the current and which is sonorous.

The circuits are clearly represented in sheet 2, wherein G represents the line which is broken to allow the receiving operator to arrange himself therein as shown. The sounding piece is also arranged in the line and is within reach of the receiving operator. F is the battery.

Erase and insert per Am'd't A, June 24, 1874.

By depressing key D, the battery current will pass through the magnet, operating in connection with the piece *a*, and the latter will then be rapidly vibrated and emit a sound. The vibration of this piece rapidly opens and closes the battery circuit, and these repeatedly interrupt the current, producing an induced current in the secondary helix. The piece *a'* may be made to operate in like manner by releasing key D and depressing key D', but the pitch of the sound emitted will be different from that produced by the piece *a*. One of the terminals of the secondary helix being grounded near the instrument, and the other connected to a line grounded at its distant end, as shown, the secondary or induced current will flow through this line when the latter is unbroken.

A noticeable effect will be produced if the receiving operator lays his hand on the sounding piece, especially if he draw his hand back and forth thereon, but a better result may be produced if the whole or a part of the service of the sounding piece is painted, or if a piece of tissue paper or its equivalent be arranged thereon. The receiving

operator must bring himself in contact with the sounding piece, or with the paint or paper thereon when either are employed, and arrange himself in the line or circuit so as to form a part thereof, it being understood that he is insulated from the ground. If the transmitting operator now depresses key D a sound will be instantly produced under the hand of the operator. The quality or tone of the sound received will depend upon the nature of the sounding piece, but the pitch will be determined by the vibrating pieces or transmitters, and may be varied in the manner described.

The uses to which the apparatus may be applied are various. In telegraphy, for example, instead of transmitting messages by means of the Morse alphabet, now in general use, tones pitched to correspond to the letters, may be employed, and these tones can be produced much more rapidly than the printed or impressed dashes could be made, and would be less in duration than the intermissions now required for that purpose. In other words, the dashes could each be denoted by a corresponding pitch of the sound received, and the time required to denote a dash could thus be no longer than that required for a dot; or, dots and dashes may both be denoted in this manner. A skillful operator capable of quickly distinguishing one pitch from another, could thus readily interpret a message. The receiving operator may, by bringing his ear (for example) in contact with the sounding piece, have both hands free to record a message. The recording may be accomplished by means of a Sholes and Glidden's type-writer, by means of which expert operators would record about eighty words in a minute. Another advantage of this system is that less than a hundredth part of the battery power now required would be sufficient for ordinary purposes. The apparatus may be employed with great advantage in connection with marine cables or wires. As a telegraph instrument, the apparatus is simple, economical and rapid in its operation.

Erase and insert per Am'd't A, June 24, 1874.

The apparatus may also be employed to transmit tunes from one place to another, the vibrating pieces being properly keyed or pitched, and sufficient in number. Even the different parts of a tune or musical composition, each simultaneously played in different places, may be transmitted to the same place so that the whole will be there audible. In the latter case, a separate circuit and transmitting and

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receiving apparatus will be required for each part of a tune, and it will also be necessary to beat time by telegraph for each set of performers.

The apparatus also affords opportunity for interesting study and experiments in acoustics in connection with electricity, and may be employed to illustrate the principles of each.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is:

Erase and insert per Am'd't A, June 24, 1874.

First. An electric circuit, having arranged therein one or more circuit interrupters, consisting of vibratory pieces, reeds, or transmitters, in combination with a sounding piece, receiver, or reproducer, for the purpose of thereby transmitting from one place to another, through living tissue, a sound, having at its destination a pitch controlled at the place of transmission.

Second. An electrical apparatus provided with one or more electrotomes controlled by corresponding keys, in combination with a sounding piece or receiver (E), arranged substantially as described with relation to the electrotomes and circuits for the purposes set forth.

ELISHA GRAY.

Witnesses:

N. C. GRIDLEY,

F. F. WARNER.

PATENT OFFICE,
APRIL 18, 1874.
U. S. A.

[Official Stamp.]

2. REJECTION.

May 18, 1874.

No. 1. EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., May 18th, 1874.

E. GRAY, care Gridley & Warner, Chicago, Ill.:

TELEGRAPH APPARATUS. 23–49. April 18, 1874.

This application was rejected for the reason that it is inoperative for the purpose claimed, and therefore of no utility. Applicant merely describes an ordinary form of induction apparatus and then merely asserts that the sound produced by its vibrating circuit-breaker will be transmitted through "living tissue" to a distant point. This assertion is not the "clear and concise" description required by the law and in view of the state of the art in telegraphy. This assertion is not sufficient to warrant the grant of a patent.

In addition the "living tissue" would have to be erased were there any patentability in the devices, as an operator can form no part of the subject of a telegraph patent.

Z. F. WILBER, *Exr.*

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3. APPLICANT'S LETTER.

June 4, 1874.

NEW YORK, May 28, 1874.

I hereby authorize A. L. Hayes, of Boston, to act as my attorney, in the matter of my application for letters-patent for an improved apparatus for Transmitting Musical Sounds by Electricity, filed April, 1874.

ELISHA GRAY.

PATENT OFFICE,
JUNE 4, 1874,
U. S. A.

[Official Stamp.]

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4. AMENDMENT A. AND LETTER.

June 24, 1874.

LETTER AMENDING.

June 24, 1874.

WASHINGTON, June 24th, 1874.

To the Honorable the Commissioner of Patents:

SIR: In the matter of the application of Elisha Gray for letters-patent for an improvement in Apparatus for Transmitting Musical Tones by Electricity, filed April 18th, 1874, I hereby amend

Am'd't A, June 24, 1874. by cancelling all of the specification except the signature of the inventor and substituting that filed herewith.

Respectfully,

ELISHA GRAY,
By his Att'y,
A. L. HAYES.

PATENT OFFICE,
JUNE 24, 1874,
U. S. A.
[Official Stamp.]

NEW SPECIFICATION.

To all who it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook, State of Illinois, have invented a new, useful and improved method of, and apparatus for, transmitting musical tones by electricity, of which the following is a full, clear and exact description thereof, which will enable others skilled in the art to which my invention appertains to make and use the same, reference being had to the accompanying drawings forming a part of and accompanying this specification.

Am'd't A, June 24, 1874.

Erase and insert per Am'd't B, Feb. 4, 1875.

Fig. 1, sheet 1, is a plan of an electrical apparatus in which my improvements are embraced. Fig. 2, sheet 1, a front elevation of

the same, and Fig. 3, sheet 2, a diagram showing an arrangement of parts and circuits which may be employed in connection with my improvements.

Like letters of reference indicate like parts in these drawings.

The nature of my invention consists in a method of producing audible musical vibrations, of any desired pitch in any suitable resonant substance which is a conductor of electricity, by transmitting through living tissue in contact with said substance a series of impulses of electricity of high tension, corresponding in number to the vibrations producing the musical tone in the said resonant substance, which impulses are generated in an induction coil or other apparatus for producing secondary induced currents of electricity, situated at any desired distance from the said resonant substance, and are caused by the vibration of any suitable circuit interrupter.

The apparatus which I prefer for carrying my invention into effect is constructed as follows, reference being had to the drawings accompanying this specification:

Am'd't A, June 24, 1874.

A represents the base or frame of the apparatus. B is an induction coil of the usual form, having the usual primary and secondary helices. C is an ordinary vibrating electrotome which when in action produces a musical tone by the vibration of its armature and circuit-breaking spring, which rate is dependent upon the length, stiffness and adjustment of the spring attached to the armature of the said electrotome. C′ is another electrotome similar to the first, with the exception that its spring is so adjusted that when in action it produces a tone of a different pitch from that produced by the electrotome C, owing to the different rate of vibration of its circuit-breaking spring.

Erase and insert per Am'd't B, Feb. 4, 1875.

Other electrotomes may be provided, having their vibrating springs so adjusted that when in action the series will give tones extending through one or more octaves.

These electrotomes are situated in the primary circuit of the induction coil, and when said primary circuit is broken by the vibration of the circuit-breaking springs, secondary currents are induced in the secondary circuit of the said coil.

D D′ are telegraphic keys of the usual form, placed in the primary circuit above referred to, which circuit is divided so that it passes

through both keys and both electrotomes. The keys are used for making connection with the battery.

Fig. 1, sheet 2, shows the arrangement of the circuits, G being the secondary circuit extending from the induction coil to the receiving station, F the battery and H the primary circuit from the battery through the keys D D,′ the magnets of the electrotomes and the primary circuit of the induction coil.

E represents a suitable resonant substance at the receiving station, and consists of a hollow cylinder of metal.

The method of operation of the apparatus is as follows:

On depressing either of the keys D D′, the primary circuit from the battery will be closed through one of the electrotomes, and its spring or circuit interrupter will immediately commence to vibrate, producing a musical tone of a certain pitch, dependent as before stated, on the size and adjustment of the vibrating spring, and interrupting the primary circuit of the induction coil. These interruptions will induce secondary currents in the secondary circuit of said coil which will correspond in number with the vibrations of the circuit-interrupter, and the number of audible vibrations constituting the tone produced.

Am'd't A, June 24, 1874.

Erase and insert per Am'd't B, Feb. 4, 1875.

Thus, for example, if the circuit-interrupting spring vibrates one hundred and twenty-eight times per second, the tone produced is that known as the "fundamental C," and at the same time one hundred and twenty-eight terminal induced currents will be generated in the secondary circuits.

If now a person places himself in said secondary circuit and places his hand or any other part of his body in contact with any resonant substance which is a conductor of electricity, so that the circuit is completed through it, said resonant substance being either a metallic cylinder like that shown at E, or a plate of metal stretched by metallic strings above the body of a violin, or a sheet of foil paper stretched over a metallic ring, or any other suitable resonant substance, the impulses of electricity transmitted through the living tissue of the operator, will, from some cause, not yet fully understood, cause a corresponding number of vibrations in said resonant substance, and a musical tone will be given forth of a quality dependent upon the character of the resonant substance, but of the same

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pitch as that produced by the vibration of the circuit interrupter at the transmitting end.

Instead of interrupting the primary circuit by automatic vibrating electrotomes and thereby inducing the secondary current of high tension, which is transmitted to the resonant receiver, the necessary interruptions for that purpose may be effected by any mechanical device by means [of] which a sufficient number of interruptions to cause a musical tone may be effected.

The secondary coil of the induction apparatus may be dispensed with, and the secondary currents induced in the primary circuit when the said primary currents are interrupted, which currents are known as "extra" currents, may be transmitted to the receiver for the purpose of causing the audible musical vibrations.

The uses to which this apparatus may be applied are various. In telegraphy, for example, instead of transmitting messages by means of the Morse alphabet, now in general use, tones of different pitch may be employed for the different signals, which tones can be produced more rapidly than printed or impressed dashes can be made, and will be of shorter duration than the intermissions now required for producing dashes and dots in succession. One tone can be used to represent a dash, and another tone a dot, or signals can be made by tones in various combinations. These signals can soon be easily learned and read by any operator capable of distinguishing tones of different pitch, who will cause the production of tones by placing his ear in contact with the resonant substance, and thus have both hands free to record the message. The signals will be received with great rapidity, and can be recorded by means of a type writer, at the rate of eighty words per minute.

Am'd't A, June 24, 1874.

Erase and insert per Am'd't B, Feb. 4, 1875.

The amount of current which is necessary to produce the effect is very small, less than one hundredth part of the battery power now required enables audible signals to be transmitted over long lines. The apparatus can be employed with advantage on submarine lines, and the rate of transmission over them can be much increased thereby.

As a telegraph apparatus it is simple, economical and rapid in its operation.

The apparatus can also be used to transmit tunes from one place

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to another, the vibrating pieces being properly pitched and sufficient in number. Even the different parts of a musical composition, each simultaneously played in different places, may be transmitted to the same place, so that the whole composition will be there audible. In this case a separate circuit and a separate transmitting and receiving apparatus will be required for each part of the tune or musical composition, and it will be necessary to beat the tune by telegraph for each set of instruments.

The apparatus can also be employed with advantage in studying the laws of acoustics and electricity.

What I claim as my invention, and desire to secure by letters-patent of the United States:

Am'd't A, June 24, 1874.

First. The method substantially as described of producing audible musical vibrations of any desired pitch in a resonant substance, which is a conductor of electricity, by transmitting through animal tissue in contact with said substance a series of electrical impulses of high tension, being secondary or extra currents induced by the interruptions of a primary circuit, corresponding in number with said vibrations.

Erase and insert per Am'd't B, Feb. 4, 1875.

Second. In combination with an apparatus for producing secondary currents of electricity, a series of vibrating automatic electrotomes or other circuit-breaking devices controlled by corresponding keys, a resonant receiver arranged in a secondary circuit substantially as and for the purpose set forth.

Third. The arrangement of two or more vibrating electrotomes in a series whose circuit-breaking spring when in action give tones of different pitch controlled by corresponding keys, substantially as and for the purpose set forth.

PATENT OFFICE,
JUNE 14, 1875.
U. S. A.

[5. RENEWAL OF APPLICATION.]

[Jan. 19, 1875.]

($15.) PETITION.

To the Commissioner of Patents:

Your petitioner represents that on April 18th, 1874, he filed an application for letters-patent for a method of transmitting musical tones by electricity, which application was allowed July 11th, 1874, but that he failed to make payment of the final fee within the time allowed by law.

He now makes renewed application for letters-patent for said invention, and prays that the original specification, oath, drawings, and model may be used as part of this application.

ELISHA GRAY,

By his Att'y,

ALEX. L. HAYES.

WASHINGTON, January 19, 1875.

PATENT OFFICE, JAN. 19, 1875, U. S. A.

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6. AMENDMENT B. AND LETTER.

Feb. 4, 1875.

WASHINGTON, Feb. 4, 1875.

The Hon. the Commissioner of Patents:

SIR: In the matter of the application of Elisha Gray for letters-patent for an improved apparatus for transmitting musical tunes by electricity, filed April 18th, 1874, I hereby amend the application by canceling the specification filed June 27, and substituting the enclosed.

Respectfully,

ELISHA GRAY,

By his Att'y,

ALEX. L. HAYES.

PATENT OFFICE, JAN. 4, 1875, U. S. A.

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To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented a new and useful Method of and Apparatus for Transmitting Vibrations by Electricity, of which the following is a full, clear, and exact description, reference being had to the drawings accompanying and forming part of this specification.

Fig. 1, sheet 1, is a plan of the electrical apparatus which I use for carrying my invention into effect.

Fig. 2, sheet 1, is a front elevation of the same, and fig. 3, sheet 2, a diagram showing an arrangement of parts and circuits which may be employed in connection with my improvements.

Similar letters of reference indicate similar parts in these drawings.

The nature of my invention consists in a method of producing audible musical vibrations of any desired pitch, in any suitable resonant substance which is a conductor of electricity, by transmitting a series of impulses of electricity of high tension, corresponding in number per second to the number of audible musical vibrations in the same time, in the tone produced through certain substances of a peculiar character, to be hereinafter described, in contact with the resonant substance, which impulses are induced in an induction coil, in either its primary or secondary circuit, or one enclosed in any primary coil, by breaking a primary circuit from a battery by any suitable circuit-closing device which breaks and closes an electric circuit as many times per second as there are audible vibrations per second in the tone produced.

Am'd't B, February 4, 1875.

Erase and insert per Am'd't C, June 22, 1875.

The following describes the construction of an apparatus which I use for carrying my invention into effect: —

A represents the base-board of the apparatus, B is an induction coil of the usual construction, provided with the usual primary and secondary helices; C is a common vibrating electrotome, having its circuit-breaking spring of such length, thickness and adjustment that it gives forth a musical tone of a certain pitch when made to vibrate; and C′ is a similar vibrating electrotome, whose spring is of different length, thickness or adjustment, so that its rate of vibration is different, and therefore produces a musical tone differing in pitch from that caused by the first. I have represented only the [two:] elec-

trotomes, but I may provide a series of the same, which, when operated will give tones extending through one or more octaves.

These electrotomes are placed in the primary circuit of the induction coil, and when an operator will cause, by induction, secondary currents in the secondary circuit of said coil, in number depending upon the rate of vibration of the circuit-breaking spring.

D D′ are telegraph keys of the usual form, which are situated in the primary circuit before referred to, said circuit being divided or branched so that it passes through both keys and both electrotomes. By means of these keys connection is made with the battery, and if a series of electrotomes is used there must be a corresponding series of keys.

In Fig. 1, sheet 2, the arrangement of the circuit is represented, G being the secondary circuit extending from the induction coil to the receiving station, F the battery, and H the primary circuit from the battery through the keys D D′, the magnet of the electrotomes and the primary circuit of the induction coil. E represents a suitable substance at the receiving station, in this case a hollow cylinder of metal.

Am'd't B, February 4, 1875.

The apparatus operates as follows, to effect the desired result: —

Erase and insert per Am'd't C, June 22, 1875.

On closing either of the keys D D′, the primary circuit from the battery will be completed through that electrotome which is connected with the key which is depressed. The circuit-closing spring of said electrotome will immediately be thrown into rapid vibration, and a musical tone of a certain pitch, dependent upon the length, thickness and adjustment of the spring, will be given forth, while at each vibration the primary current in the primary circuit of the induction apparatus will be interrupted. These interruptions induce corresponding secondary currents in the secondary circuit of the induction apparatus, and these secondary induced currents are transmitted to the receiving station.

Thus, for example, if the circuit-breaking spring of the electrotome vibrates one hundred and twenty-eight times per second, the tone given forth is that known as the fundamental C, while one hundred and twenty-eight terminal secondary currents will be induced in the secondary circuit of the induction apparatus.

If, now, one of the terminals of these secondary circuits be con-

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nected to a substance having certain specific characteristics, which are that it be a conductor of electricity, that it be yielding and elastic, and that on the surface it be of greater resistance than in the interior, and which characteristics are found in the skin of the human body, in leather moistened with acidulated water, in animal flesh covered with a membraneous coating, in bacon-rind, in pork skin, especially a piece from the ear or tail, and in other substances which need not be enumerated, and the said terminal be brought into contact with the resonant substance, which is also in contact with the terminal, so that the electric circuit is completed through the said substance, the electric impulses transmitted through the substance in contact with the metallic plate or resonant article will by some unexplained cause throw the same into synchronous vibration, and it will give forth a musical tone containing the same number of audible vibrations per second as there are impulses transmitted per second, and consequently of the same pitch as the tone produced by the vibrating circuit-closer at the transmitting station.

Am'd't B, February 4, 1875.

In place of a cylinder of metal for receiving the vibrations I can use a metallic plate, stretched by metallic strings above any sounding-board, such, for instance, as a violin body.

Erase and insert per Am'd't C, June 22, 1875.

Thus it is seen tones are produced at the receiving station simultaneously with and corresponding to those produced at the transmitting station.

The interruptions in the primary circuit, which cause the induced secondary currents, may be produced by a mechanical circuit-closer, moving with sufficient rapidity, or they may be produced by providing the vibrating reed of an organ with contact points, so that, as the reed vibrates, it will transmit impulses corresponding in number per second to the number of audible vibrations per second in the note sounded by the organ-pipe.

The secondary coil is not necessary, but the secondary currents induced in a primary coil may be used.

The amount of current which is necessary to affect the production of tones in the vibrating plate is quite small, less than one-hundredth part of the battery power now required for transmitting signals being sufficient to transmit signals over long land-lines.

Signals can also be transmitted with great facility and rapidity through submarine cables by this method.

By means of this apparatus melodies can easily be transmitted, which melody is played by depressing the keys connected with the electrotomes, and is reproduced on the vibrating plate or other resonant substance at the receiving station.

The method can be used for telegraphing with advantage. Instead of the Morse alphabet now in use, messages may be given by using tones of different pitch for the different letters, and an alphabet can be constructed on this principle.

By means of this apparatus the different parts of a musical composition may be transmitted to the same place from different places, when each part is played by independent circuits and separate transmitting and receiving apparatus will be required for each part.

The apparatus can also be employed with advantage in studying acoustics and the physical theory of music.

What I claim as my invention and desire to secure by letters-patent is: —

Am'd't B, February 4, 1875.

Erase and insert per Am'd't C, June 22, 1875.

First. The method, substantially as described, of producing audible musical vibrations of any desired pitch by transmitting a series of currents of high-tension electricity through certain substances of certain specific character hereinbefore specified, in contact with the resonant substance, the said currents of high tension being induced on secondary currents and caused by interrupting by the primary circuit of an electro-magnet by suitable circuit-closing devices breaking said primary circuit as many times per second as there are audible vibrations per second in the tone produced.

Second. In combination with an apparatus for producing secondary circuits of electricity, a series of vibrating automatic electrotomes, controlled by corresponding keys and resonant substance arranged in a secondary circuit, substantially as and for the purpose set forth.

Third. The arrangement of two or more vibrating electrotomes, in a series whose circuit-breaking springs, when in action, give tones of different pitch and are controlled by corresponding keys, substantially as set forth.

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7. OFFICE LETTER.

March 29, 1875.

No. 1. 67–47.
Copy sent March 29.
I. R. A.

EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., March 28, 1875.

E. GRAY, care A. L. Hayes, Boston, Mass.

ELECTRIC APPARATUS FOR TRANSMITTING SOUND. Filed April 18, 1874; renewed Jan. 19, 1875.

In this case there is some indefiniteness in the first claim, arising from the sentence, "certain substance of certain specific character hereinbefore specified." The substances should be set forth so as to be identified, as was done in the original claim. The substitution of the words "animal tissue" would accurately define the gist of the sentence objected to.

On the 8th page reference is made to a "mechanical circuit breaker," but none is shown nor fully described.

Another applicant shows, fully describes and claims mechanical circuit breakers in this connection. If applicant desires any interference thereon he should file an amendment to this case (or to that filed originally, June 27, 1874, in which the same thing is mentioned), showing what he had in this line at the date of filing the application. Otherwise it is not seen that an interference on this point can be had, regard being had to the rights of the other applicant.

Z. F. WILBER, *Ex'r.*

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8. AMENDMENT C. AND LETTER.

Case 1.

(FORM NO. 6.—POWER OF ATTORNEY.)

In the United States Patent Office.

In the matter of the application of Elisha Gray, of Chicago, Illinois, for letters-patent of the United States for Electric Apparatus for Transmitting Sound. Filed April 18, 1874.

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WASHINGTON, June 11, 1875.

To the Commissioner of Patents:

The undersigned hereby makes, constitutes and appoints William D. Baldwin, of Washington City, in the District of Columbia, his attorney, with full power and authority of substitution and revocation, to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business connected therewith in the Patent Office, and hereby revokes any and all powers of attorney heretofore given.

ELISHA GRAY.

I concur in the above. SAMUEL S. WHITE.

PATENT OFFICE, JAN. 12, 1875, U. S. A.

[Official Stamp.]

LETTER TO OFFICE.

(FORM NO. 3. — LETTER TO OFFICE.)

In the United States Patent Office.

In the matter of the application of Elisha Gray for Letters Patent for Electric Apparatus for Transmitting Sounds. Filed April 18, 1874.

WASHINGTON, D. C., June 22, 1875.

To the Commissioner of Patents.

SIR: In view of official suggestions, an amended specification is herewith filed, in the above-mentioned application, without waiving applicant's rights in the premises. Applications will hereafter be filed claimnig the Multiple Transmitter, the Mechanical Circuit Breaker, and the Organ Pipe Circuit Interrupter.

Respectfully yours,

ELISHA GRAY.

By his Att'y,

WM. D. BALDWIN.

PATENT OFFICE, JUNE 22, 1875, U. S. A.

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Case —

(FORM NO. 2.—AMENDMENT.)

In the United States Patent Office.

In the matter of the application of Elisha Gray for Letters Patent for Electric Apparatus for Transmitting Sounds. Filed April 18, 1874.

WASHINGTON, D. C., June 21, 1875.

To the Commissioner of Patents:

SIR: Amend the specification of the above mentioned application, as follows: *Erase* the *entire specification* and all amendments heretofore filed, and *substitute* in lieu thereof the following, to wit:

SPECIFICATION.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and state of Illinois, have invented a new and useful Art of Transmitting Musical Impressions or Sounds Telegraphically, as well as certain new and useful improvements on apparatus for so transmitting such impressions or sounds, of which art and apparatus I hereby declare the following to be a full, clear and exact description:

Am'd't C, June 22, 1875.

My invention relates to a novel art of transmitting musical impressions or sounds telegraphically, which impressions or sounds may be utilized as signals for the transmission of intelligence.

My invention is based upon the well-known law of acoustics, that bodies vibrating with different rapidity produce tones of different pitch; and upon my own discovery that such vibrations can be transmitted through a telegraphic circuit and reproduced, in a musical tone or note of a pitch corresponding with that originally transmitted, by including in the circuit animal tissue or other equivalent substance, which will cause a slight resistance to the electrical current at the point of contact between such animal tissue and some resonant conductor of electricity.

My improvement consists in a new and useful art of producing musical impressions or sounds at the transmitting end of a telegraphic

circuit, by causing interruptions in the electric currents of sufficient frequency to produce musical tones; transmitting said tones through an electric circuit composed in part of animal tissue and reproducing them at the receiving end of the line by means of a resonant body which is also a conductor of electricity.

My improvement further consists in a new and useful apparatus for carrying out the objects of my invention, which apparatus consists of the combination of a telegraphic circuit composed in part of animal tissue, a circuit-breaker capable of producing a musical tone, and a receiver capable of reproducing that tone at the receiving end of the circuit.

My improvement further consists of the combination in an apparatus such as described, of a series of circuit-breakers capable of producing musical tones of different pitch, and a series of keys for simultaneously or successively throwing the circuit-breakers into or out of operation; whereby several tones, simultaneously or successively, may be transmitted through a single wire.

The subject-matter claimed will hereinafter specifically be designated.

Am'd't C, June 22, 1875.

In the accompanying drawings —

Figure 1 represents a plan or top view of a portion of the transmitting apparatus;

Figure 2 is a front elevation of the same; and

Figure 3 a diagram showing an arrangement of parts and circuits which advantageously may be employed in working my invention.

The transmitting apparatus is mounted, as usual, upon a base-board, A. An induction coil, B, is provided with primary and secondary helices of the usual construction. A common vibrating electrotome C, having its circuit-breaking spring, *a*, of such length, thickness and adjustment that its vibration produces a musical tone of a certain pitch, forms part of the circuit.

It is obvious that the apparatus may be worked with a single electrotome, the pitch of which may be varied by adjustment; but where a series of tones of different pitch is desired, I prefer to employ a series of electrotomes having different rates of vibration.

Two electrotomes, C C′, of identical construction, but differing in

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pitch, are shown in the drawings; but I propose, under some circumstances, to use a series of electrotomes which will give tones extending through one or more octaves. These electrotomes are by preference placed in the primary circuit of the induction coil, and when in operation induce secondary currents or impulses in the secondary circuit of said coil, equal in number to the vibrations of the circuit-breaking spring of the electrotome.

An ordinary telegraph key, situated in the primary circuit, opens or closes the connections of the battery. Each electrotome must have a corresponding key. In the drawings two keys, D D′, are shown, both of which, as well as the electrotomes, are situated in the primary circuit, which is divided or branched in order to pass through them.

Figure 3 shows the arrangement of the circuits. The primary circuit, F, connected with the battery E′, passes through the keys D D′, the magnets of the electrotomes and the primary circuit of the induction coil B. One terminal of the secondary circuit, G, extends from the induction coil to the receiving station through animal tissue to a suitable resonant conductor of electricity, which is in this case a hollow metallic cylinder, H, which is connected with the ground; the other terminal, I, of the induction-coil passes directly to the ground in the ordinary way.

Am'd't C, June 22, 1875.

The animal tissue interposed between the wire and the resounding receiver to complete the circuit is shown in the drawings, as consisting of the body of the receiving operator, who must be insulated from the ground; but other substances may be employed, which must possess the specific characteristics of being conductors of electricity, of being yielding and elastic, and of having a surface of greater electric resisting capacity than its interior.

These characteristics are found in the skin of the human body; in leather moistened with acidulated water; in animal flesh covered with a membraneous coating; in bacon-rind; in pork skin, especially pieces taken from the ear or tail; in kid gloves, and in other substances, which need not be enumerated, as they do not act so perfectly as those above given.

The operation of the apparatus is as follows:

The closing of either of the keys completes the primary circuit

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from the battery through the electrotome connected with the key depressed, and the circuit-closing spring of said electrotome will immediately be thrown into rapid vibration, and a musical tone of a certain pitch, dependent upon the length, thickness and adjustment of the spring, will be given forth, while at each vibration the current in the primary circuit of the induction apparatus will be interrupted. These interruptions produce corresponding secondary currents or impulses in the secondary circuit of the induction apparatus, and these secondary induced currents or impulses are transmitted to the receiving station; thus, for example, if the circuit-breaking spring of the electrotome vibrates one hundred and twenty-eight times per second, the tone given forth is that known as the "fundamental C," while one hundred and twenty-eight terminal secondary currents or impulses will be induced in the secondary circuit of the induction apparatus and transmitted through the animal tissue above mentioned, forming part of said circuit, to the resonant receiver; and will, from some cause not understood or explicable in the present stage of the art, vibrate the same synchronously with the transmitting electrotome and thus give forth a musical tone of the same pitch.

Am'd't C, June 22, 1875.

A metallic plate stretched by metallic strings above a sounding board, such, for instance, as the body of an ordinary violin, may be used with good effect to receive the vibrations instead of the hollow cylinder above described.

From the foregoing description it will be seen that musical tones produced at the transmitting station, can simultaneously be produced at the receiving station, however distant. When two or more keys are simultaneously or successively depressed, corresponding tones will simultaneously be transmitted, thus producing harmony or melody.

The interruptions in the primary circuit which cause the induced secondary currents or impulses may be produced by a mechanical circuit-breaker, having the requisite rapidity of motion, such as a revolving wheel or revolving brush; or they may be produced by providing the vibrating reed or reeds of an organ with contact-points, so that, as the reed vibrates, it will transmit impulses corresponding in number per second to the number of vibrations per second of the note sounded by the organ-pipe.

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I prefer to use the impulses of the induced secondary currents as the transmitting medium, as such use affords the most convenient way of obtaining electricity of high tension, which is that best adapted for penetrating a slightly resisting medium, such as the animal tissue hereinbefore mentioned.

The secondary coil is not essential, as the secondary circuit induced in the primary coil may be utilized for transmitting the signals.

My improvement enables me to operate with a very slight amount of current, as the battery power required to produce and transmit the vibrations is less than one hundredth part of the battery power now required to transmit signals over long land-lines.

My improved method can advantageously be substituted for the Morse telegraph alphabet, now in general use, as an alphabet can be constructed on the principle of using tones of different pitch for the different letters, which will admit of great rapidity of transmission.

Am'd't C, June 22, 1875.

By means of my improved apparatus, not only may a tune be transmitted by a single operator to a distant point, but the different parts of such tune simultaneously may be reproduced at a common point from different places, a separate part of the tune being played at each place.

The apparatus can advantageously be employed in studying acoustics and the physical theory of music.

[*Insert per Amendment D, July* 20, '75.]

I claim as of my invention:

1. The hereinbefore described art of transmitting musical impressions or sounds telegraphically by producing musical impressions or sounds at the transmitting end of a telegraphic circuit by causing interruptions in the electric currents of sufficient frequency to produce musical tones, transmitting said tones through an electric circuit composed in part of animal tissue, and reproducing them at the receiving end of the line by means of a resonant body which is also a conductor of electricity, substantially as set forth.

2. I also claim the electro-harmonic telegraph apparatus hereinbefore set forth, consisting of the combination of a telegraph circuit composed in part of animal tissue, a circuit-breaker capable of pro-

ducing a musical tone, and a resonant conductor of electricity capable of reproducing that tone at the receiving end of the circuit.

3. I also claim the combination substantially as hereinbefore set forth, of a telegraphic circuit composed in part of animal tissue, a resonant receiver which is also a conductor of electricity, a series of circuit-breakers capable of producing musical tones of different pitch, and a corresponding series of keys for throwing the circuit-breakers into or out of operation, whereby several tones simultaneously may be transmitted through a single wire.

Am'd't C, June 22, 1875.

ELISHA GRAY.

Witnesses:
WM. J. PEYTON,
E. C. DAVIDSON.

CITY AND COUNTY OF WASHINGTON,
DISTRICT OF COLUMBIA.

Elisha Gray, whose application for letters-patent for an electric apparatus for transmitting sounds, was filed in the Patent Office, April 18, 1874, being duly sworn, deposes and says, that he verily believes himself to be the original and first inventor of the improvement as described and claimed in the foregoing amendment, and that he does not know and does not believe that the same was ever before known or used.

ELISHA GRAY.

Sworn and subscribed to before me, this 21st day of June, A. D. 1875.

DELOZIER DAVIDSON, *Notary Public.*

NOTARIAL SEAL.

PATENT OFFICE, JUNE 22, 1875. U. S. A.

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9. OFFICE LETTER.

July 7, 1875.

Copy sent July 7.
S. R. A.

EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., July 7, 1875.

ELISHA GRAY, care W. D. Baldwin, Present.

ELECTRIC APPARATUS FOR TRANSMITTING SOUND. January 19, 1875.

As this case is amended and limited to the form in which animal tissue is an integral part, it is thought to be clear of the proposed interference, so far as the claims now made are concerned. Certain matters are shown, however, which are claimed in other applications; this still necessitates an interference or else a disclaimer on applicant's part. Then matters are "the combination with a main line of an intermittent circuit-breaker or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each such circuit-breaker."

Z. F. WILBER, *Ex'r.*

(FORM NO. 2 — AMENDMENT.)

In the United States Patent Office.

In the matter of the application of Elisha Gray, for Letters-Patent for Electric Apparatus for Transmitting Sound. Filed January 19, 1875. "Case 1." (Originally filed April 18, 1874.)

WASHINGTON, D. C., July 20, 1875.

To the Commissioner of Patents:

SIR: Amend the specification of the above mentioned application as follows.

Page 8, after line 12, insert the following disclaimer:

"The combination with a main line of an intermittent circuit-breaker or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each such circuit-breaker are not broadly claimed herein, as they constitute a part of the subject-matter of another application for letters-patent of the United States, filed by me, February 23d, 1875."

Am'd't D, July 20, 1875.

The above amendment is submitted in view of the official letter of July 7, 1875, in order to avoid the delay of an interference which can be as well contested under the application in favor of which this disclaimer is made.

Very respectfully,
ELISHA GRAY,
By his Att'y,
WM. D. BALDWIN.

PATENT OFFICE,
JULY 20, 1875,
U. S. A.

[Official Stamp.]

MEMORANDUM OF FEE PAID AT
U. S. PATENT OFFICE.

Inventor,
E. GRAY.

Patent to be issued to
S. S. WHITE & GRAY, *As'ees.*

INVENTION,
Electric Apparatus for Transmitting Sounds. (Case 1.)

DATE OF PAYMENT,
July 24, '75.

Second Fee,
$20.

SOLICITOR,
Wm. D. Baldwin.

3754

1874.

Renewal: WILBER. 67
47

No. 166,096. Div. 18.

ELISHA GRAY,

Assigner of ½ his right to Samuel S. White, of Philadelphia, Pa.
Of - - - Chicago, - - - - -
County of - - Cook, - - - - -
State of - - Illinois. - - - - -

ELECTRIC APPARATUS FOR TRANSMITTING SOUND.

	Rec'd, - -	April 18, 1874. - - -	
	" - -	Jan. 19, 1875. - - -	
	Petition, - -	" " " - - -	
	" - -	" " " - - -	
	Affidavit, - -	" " " - - -	
	Specification, -	" " " - - -	
	Drawing 2 sheets,	" " " - - -	
	Model, - -	" " " - - -	
	Cert. dep., - -	- - - - - -	
1	Cash, $15, - -	April 18, 1874. - - -	
	" $15, - -	Jan. 19, 1875. - - -	
	Add'l Fee Cert. -	- - - - - - -	
1	" " Cash $20,	July 24, 1875. - - -	
	Examined -	July 10, 1874. - -	Wilber.
2	Issue - -	July 24, 1875. - -	Wilber.
	" - -	" " " - -	Knight.
3	Patented - -	July 27, 1875. - - -	
	Recorded - -	vol. page. - - -	
	Circular - -	July 11, 1874. - - -	

W. D. BALDWIN,
Present.

37555

1874.

CONTENTS.

1.	Application.	1 paper.
2.	Rejection,	May 18, 1874.
3.	Applicant's Letter,	June 4, 1874.
4.	Amd't A and Letter,	June 24, 1874.
5.	Passed,	July 10, 1874.
6.	Amendment B,	February 4, 1875.
7.	Letter,	March 29, 1875.
8.	Amd't C, and Letter,	June 22, 1875.
9.	Letter,	July 7, 1875.
10.	Amendment D,	July 20, 1875.
11.	Briefed,	July 24, 1875.
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		

8 Title:

IMPROVEMENT IN ELECTRIC TELEGRAPHS FOR TRANSMITTING MUSICAL TONES.

Ex'd, J. A. W.
S. P. P.

163

375e

"DEFENDANT'S EXHIBIT GRAY'S ORGAN-PIPE TRANSMITTER PATENT."

[INTRODUCED RECORD, PAGE 362.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN AUTOMATIC CIRCUIT-BREAKERS FOR ELECTRO-HARMONIC TELEGRAPHS.

Specification forming part of Letters Patent, No. 173,460, dated February 15, 1876; application filed January 8, 1876.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented a new and useful Improvement in Automatic Circuit-Breakers for Electro-Harmonic Telegraphs, of which the following is a specification:

My invention relates to electro-harmonic telegraphs of the class secured to me by Letters-Patent of the United States, numbered respectively 176,095 and 166,096, granted July 27, 1875. Its object is to produce a simple and effective circuit-breaker vibrating automatically with sufficient rapidity to produce a musical tone of a given pitch, the electrical impulses thus generated being transmitted through an electric circuit and reproduced at the other end of the line as set forth in my patents above mentioned; to which end my improvement consists in combining with an organ, or other wind-pipe, a diaphragm vibrated by sounding said pipe, and an electric circuit connected with said diaphragm so as to be opened and closed by its vibrations.

In the accompanying drawings, which exemplify one of the best ways now known to me of carrying out the objects of my invention, Figure 1 represents a plan view of my improved apparatus; Fig. 2, a side view; and Fig. 3, a longitudinal vertical section therethrough on the line *x x* of Fig. 1.

An organ-pipe, A, is shown as made with an opening, *a*, in its side, over which a membranous diaphragm, *b*, is stretched. One wire of the circuit is connected with a binding-post, C, from which a

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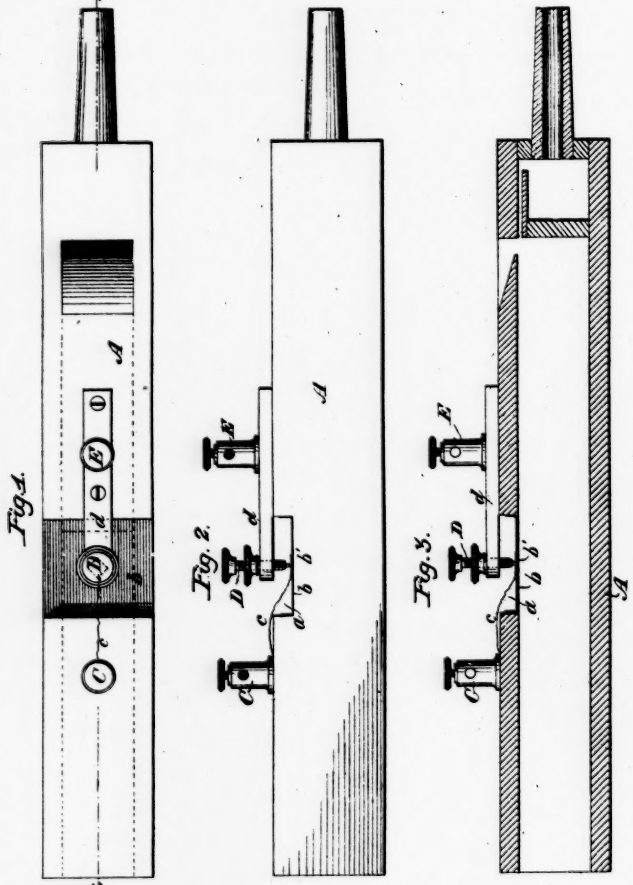
E. GRAY.

AUTOMATIC CIRCUIT-BREAKERS FOR ELECTRO-HARMONIC TELEGRAPHS.

No. 173,460. Patented Feb. 15, 1876.



Witnesses
Baltis & Long
F. Stich

Inventor.
ELISHA GRAY

By his Attorney
W. D. Baldwin

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wire, *c*, leads to a platina point, *b'*, on the diaphragm underneath a set-screw, D, mounted on a bar or frame, *d*, connected with a binding-post, E, to which the other wire of the circuit is attached.

When the column of air in the pipe is vibrated by sounding the pipe, the diaphragm will vibrate correspondingly with the musical tone thus produced, and open and close the circuit accordingly, thus transmitting the vibrations to the receiving instrument for utilization, as mentioned in my patents before referred to.

Obviously the vibrations of several pipes giving notes of different pitch may be simultaneously transmitted through a single wire by suitable mechanism.

I claim —

The combination, substantially as hereinbefore set forth, of an organ-pipe, a membranous diaphragm vibrated by sounding said pipe, and an electric circuit opened and closed by said vibrations.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

ENOS M. BARTON,
GEO. H. BLISS.

"DEFENDANT'S EXHIBIT GRAY SOUNDING-BOX RECEIVER PATENT."

[INTRODUCED RECORD, PAGE 67.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN TELEPHONIC TELEGRAPH APPARATUS.

Specification forming part of Letters Patent, No. 175,971, dated April 11, 1876; application filed January 8, 1876.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in the Art of Transmitting Musical Sounds Telegraphi-

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cally, as well as certain new and useful improvements on apparatus for so transmitting such sounds, of which art and apparatus the following is a specification:

My invention relates to electro-harmonic telegraphs of the class shown and described in Letters Patent of the United States granted to me July 27, 1875, and respectively numbered 166,095 and 166,096, and in an application for Letters Patent filed by me February 23, 1875.

The object of my invention is to dispense with local batteries and sounders, and all adjustment at the receiving end of the line, which end I attain by means of an apparatus which analyzes composite tones transmitted electrically through a wire, whereby the operator is enabled to read directly from the tone transmitted.

The subject matter claimed hereinafter specifically will be designated.

In the accompanying drawings, which show so much of my improved apparatus as is necessary to illustrate the invention herein claimed, Figure 1 is a plan or top view, and Fig. 2 a side elevation, partly in section, of one of my improved sounders or receivers. Fig. 3 is a diagram, showing my improved transmitting and receiving appartus as adapted to the transmission of severel tones simultaneously.

A resonant-box, A, such as used for intensifying the sound of tuning-forks, is shown as closed at one end. A screw-bolt, D, or other suitable support secured upon this box, sustains an electro-magnet, B, of well-known construction. A vibrating tongue or reed, C, of steel, is also fastened upon the support D, and is united with one pole of the magnet B. The free end of the reed passes close to, but does not touch, the other pole of the magnet.

For convenience of removal or replacement, all the parts of the apparatus may be united by means of a common bolt and nut, E.

The box is tuned to produce a maximum resonance of the desired tone, and the reed is accurately tuned correspondingly. Consequently, as the reed vibrates, the sound of its fundamental tone is intensified by the resonance of the box in accordance with well-known laws of acoustics.

If, now, the electro-magnet be connected in a telegraphic circuit in

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2 Sheets—Sheet 1.

E. GRAY.

TELEPHONIC TELEGRAPH APPARATUS.

No. 175,971. Patented April 11, 1876.

Fig 1

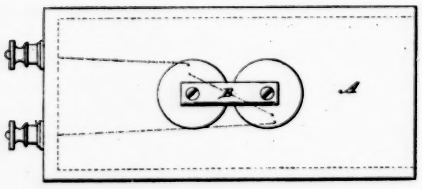
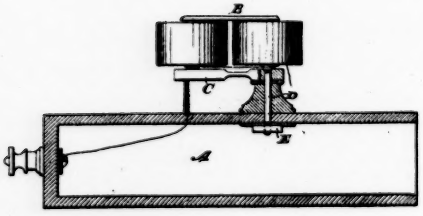


Fig 2.



WITNESSES

Wm Aeshinkle
F. Smith

By his Attorney

INVENTOR

Elisha Gray.

Wm D. Baldwin

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2 Sheets—Sheet 2.

E. GRAY.

TELEPHONIC TELEGRAPH APPARATUS.

No. 175,971. Patented April 11, 1876.

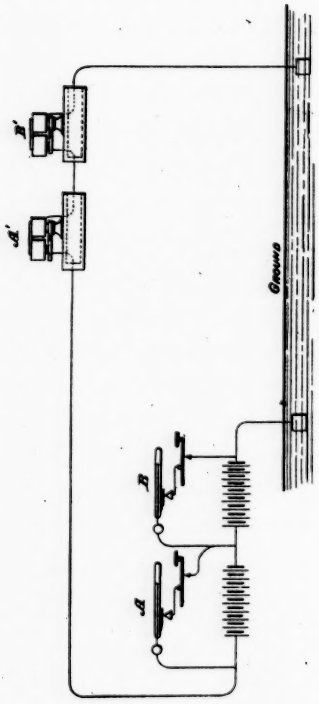

Fig 3.

WITNESSES

Wm A Smith

Baltis & Long.

By his Attorney

INVENTOR

Elisha Gray

Wm. Baldwin

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the same way as one of my analyzers described in the application aforesaid, and the note be transmitted by means of one of my transmitters described in said application for Letters Patent, the note will sound in the box, provided the tone transmitted corresponds with that of the box; otherwise the note will not be heard. Should a second analyzer be similarly placed in the circuit and tuned to a different pitch, and a second note of corresponding pitch be transmitted, it will sound in the box of corresponding pitch without affecting the other. The same rule holds with a larger number.

I have in practice thus analyzed and reproduced as many as eight different tones simultaneously transmitted through a single wire; and, as I have demonstrated, by using the Morse signals eight messages can simultaneously be sent over each wire as rapidly as each operator can transmit with the common telegraphic key, the advantages of my invention are obvious.

I believe it, however, to be practicable simultaneously to transmit a number of messages even greater than that above mentioned.

The reed C is made of a steel bar with parallel sides, the tuning being done by cutting away the sides near the fixed ends, as shown in the drawings. I find this construction, in practice, to obviate the tendency of the reeds to break into notes, or to respond to notes other than their own, as has been the tendency of other forms of reeds tried by me.

I claim as my invention —

1. The hereinbefore described art of transmitting musical sounds telegraphically by reproducing such sounds at the receiving end of the line by means of a vibrating reed and a sounding-box of corresponding pitch.

2. The combination, substantially as hereinbefore set forth, of an electro-magnet, a vibrating reed, and a sounding-box of corresponding pitch, united at the receiving end of an electric circuit.

3. The combination, substantially as hereinbefore set forth, with an electric circuit, of a series of electro-magnets, a series of vibrating reeds, producing musical tones of different pitch, and a series of correspondingly tuned sounding-boxes, whereby each box is caused to sound its own note while rejecting all others.

4. The vibrating reed, constructed as hereinbefore set forth, with

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parallel sides, and with recesses near its fixed end, whereby its tendency to vibrate in unison with tones other than its own is prevented.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

ENOS M. BARTON,
GEO. A. BLISS.

"DEFENDANT'S EXHIBIT GRAY'S PRINTER PATENT."

[INTRODUCED RECORD, PAGE 68.]

ELISHA GRAY, OF CHICAGO, ILL., ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY, OF NEW YORK CITY.

IMPROVEMENT IN ELECTRO-HARMONIC PRINTING TELEGRAPHS.

Specification forming part of Letters Patent, No. 179,549, dated July 4, 1876; application filed April 12, 1876.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented a new and useful Art of Electro-Harmonic Telegraph-Printing and an Improved Electro-Harmonic Telegraph Printing Apparatus, of which the following is a specification:

My present invention is based upon a system of electro-harmonic telegraphy described in sundry Letters Patent of the United States granted to me within the past year, and in various applications for Letters Patent of the United States made by me, and now pending.

The objects of invention are, first, to adapt my electro-harmonic system of telegraphy to the printing of a message by means of independently-movable type, and by means of mechanism thrown into action by the depression of a key at the transmitting station, without necessitating the employment of isochronously-moving type-wheels,

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or of waiting for mechanism to register accurately before printing; second, to print a message on a letter-sheet, type-writer fashion, by the direct operation of keys at the transmitting station controlling local batteries actuating the printing mechanism; third, to transmit a series of tones of different pitch through an electric circuit, each tone independently actuating a local battery, to print a letter, sign, or character corresponding with that of the particular key controlling the tone; fourth, to determine, in advance, through the action of a local battery, which one of a series of letters, numbers, or characters, actuated by a common motor, shall be printed; fifth, to determine, in advance, the point on the letter-sheet at which the printing of the message shall begin; sixth, to move a particular type to the point at which the printing is done, and there to make its impression upon the paper by means of mechanism thrown into action by the movement of the type itself; seventh, to feed the paper upon which the message is printed by mechanism thrown into operation by the printing of the preceding letter; eighth, to determine, in advance, what particular letter of a series shall be printed, to actuate the printing mechanism by the movement of the particular type selected, and to actuate the feeding mechanism by the type thus selected; and, ninth, to control the printing mechanism by means of a compound magnet constituting, in fact, a single one.

These objects I attain by certain novel apparatus hereinafter set forth, the novel construction and combinations of which apparatus form a portion of the subject matter of my invention, which is hereinafter specifically designated.

The accompanying drawings represent an apparatus embodying all my improvements in the best way now known to me. Obviously, however, the details of construction of the apparatus may be greatly varied in various ways without departing from the principle of my invention; and some of my improvements may be used without the others, and in apparatus differing in construction from that herein shown.

My improved apparatus consists of two main portions, — a transmitter and a receiver.

Figure 1 represents a plan or top view of the transmitter, with portions of the casing removed, to show the internal construction

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more clearly. Fig. 2 represents a vertical longitudinal section through the transmitter, on the line 1 1 of Fig. 1. Fig. 3 is a bottom plan view of the transmitter, showing the method of running the circuits. Fig. 4 is a back view of one set of transmitting reeds. Fig. 5 is a diagram showing the method of running the main and local circuits through a single transmitting-key and vibrating reed of a series. Fig. 6 is a plan or top view of the receiving apparatus, on the line 2 2 of Fig. 10. Fig. 7 is a bottom plan view of the top plate of the receiver. Fig. 8 is a vertical longitudinal section therethrough, on the line 4 4 of Fig. 7. Fig. 9 is a transverse section on the line 5 5 of Fig. 8. Fig. 10 is a vertical longitudinal section on the line 3 3 of Fig. 6. Fig. 11 is a top view of the apparatus for carrying the paper, and Fig. 11^a is a vertical transverse section therethrough on the line 6 6 of Fig. 11. Fig. 12 is a detail view of a portion of the local circuit-breaking mechanism which releases the paper-carrying mechanism. Fig. 13 is a similar view of another portion of the same apparatus. Fig. 14 is a detail view of the paper-feeding apparatus for spacing the lines of the message. Fig. 15 is a bottom plan view of the parts shown in Fig. 6, showing the mode of running the circuits. Fig. 16 is a detail view showing the method of running the circuits of the printing and paper-feeding mechanism. Fig. 17 is a skeleton diagram of the receiving and transmitting mechanisms, showing the method of connecting the circuits. Fig. 18 is an end view, and Fig. 19 a side view, of the compound analyzing-receiver. Figs. 20 and 21 are detail views of the shunting-pins of the analyzing spring, and Fig. 22 shows a plan view of a star-wheel, for actuating the type-shifting levers, detached.

The transmitting apparatus shown in the accompanying drawings is substantially similar, in its general construction, to that shown in Letters Patent of the United States, granted to me February 16, 1876, as No. 173,618, with the exception hereinafter stated.

In this instance the apparatus is designed for printing twenty-seven characters, and for operating a tripping apparatus, whereby the printing mechanism at the receiving end of the line may be automatically restored to its normal position during any portion of its operation of printing a line.

In order to avoid the complication of using twenty-eight different

keys and their corresponding transmitting reeds, I have devised means whereby the whole twenty-eight characters may be transmitted by the employment of nine primary keys, three shifting keys, and a "trip key," thus reducing the number of keys employed more than one half.

The primary keys are each marked with three letters, numbers, or characters, and together with the trip-key and shifting-keys are arranged organ-fashion, as shown in Fig. 1, on a suitable base board or frame, A, upon which the transmitting-reeds are mounted, in the manner shown in the drawings.

In order to secure convenience of construction, and a compact arrangement, the series of transmitting-reeds are arranged in two sets, B B′, of similar construction mounted upon the base-board of the frame, as shown.

The broken lines in Fig. 1 represent the connection of the keys with the transmitters. Fig. 3 shows a view of the connections as arranged beneath the base-board directly under the transmitters. Fig. 5 shows a method in which the main and local batteries are connected with a single key and vibrating reed of the circuit. Each one is a duplicate of the other, and their circuit connections are substantially similar to those shown and described in my patent of February 16, 1876, above mentioned; and as they, moreover, will be readily understood from the figure, a detail description of the construction and operation of these parts is deemed unnecessary.

In the operation of this apparatus the circuit is normally open, but the depression of any key connects the main battery to line through its corresponding transmitter. Each of the thirteen keys above mentioned has its own independent analyzer at the receiving end of the line.

In the present arrangement the organization is such that there are twenty-seven printing-type at the receiving end of the line, corresponding with the lettered keys, as will hereinafter be more fully explained.

These type are arranged in sets of three, one of each set being operated by each lettered key. Which one of these three letters shall be printed is determined by depressing one of the shifting-keys 1 2 3, which operate the type-shifting mechanism of the receiver in such

manner that, in the present instance, when the key 1 is depressed, the depression of the lettered keys will print the letters on the row included between the letters E and N in Fig. 1. When key 2 is depressed, the middle row of letters only will be printed at the receiving end of the line; and when key 3 is depressed, the type corresponding with the outer row only will be acted upon. When the key marked "trip" is depressed, it operates to restore the paper-carrying mechanism to its normal position or starting-point, as will be hereinafter more fully explained.

In the organization shown in the drawings the keys 1 2 3 are operated independently of the lettered keys or trip-key; but when either of said numbered keys is depressed, it makes no difference where the lettered keys are touched, as they can only print the letter of the row corresponding with the numbered key depressed.

As a modification of this device I contemplate so constructing and combining the keys that each letter shall be mounted on an independent movable section, attached to the key by a movable connection, in such manner that when a particular letter is depressed it shall operate the correspondingly-numbered key, and thus cause it to shift the proper type without the necessity of touching both the lettered and the trip-key, as is necessary under the organization shown in the drawings.

This result can readily be attained in two ways; first, by means of a contact-point on the key which shall close the circuit or tone of the properly-numbered key, thus actuating the type-shifter at the receiving end of the line before the lettered key closes its own circuit to actuate the type. This result may also be attained by combining levers or other suitable devices connecting each key with the contact-point of the numbered key, although I prefer the first-mentioned plan, as being less complicated.

The manner in which the transmitters and receivers are connected will readily be understood by inspection of Fig. 17, in which 1, 2 and 3 represent the numbered keys, and N W a lettered key. It should be stated, however, that the local battery of the transmitter is omitted in this figure, to avoid complication, but it is shown in Fig. 5. The depression of either key closes both the main and local circuits of the transmitter, and sends to line vibra-

tions or impulses of the electro-tone or vibrating reed corresponding with the key. These vibrations pass through the magnet C C^1 of the analyzing-receiver, and are reproduced on the corresponding vibrating tuned bar or reed 1 2 3 or N W. Each bar is provided with a circuit-breaking lever, *b*, vibrating more slowly than the bar, as described in Letters Patent No. 166,094, granted to me July 27, 1875. These circuit-breaking levers control a local battery, L B, No. 1, which remains normally closed, and is short-circuited through the vibrating bars or analyzing-springs and levers above mentioned. Each analyzing-spring is provided with a loop passing through a corresponding local magnet, 1, 10, 11, or 12, the terminals of which loop connect, respectively, to the analyzing-spring and with its circuit-breaking lever, so that when the circuit-breaking lever is out of contact with its vibrating-bar the shunt or short circuit is taken off from its corresponding magnet, and the current flows through the magnet; but when the vibrating-bar and circuit-breaking lever are in contact, the shunt comes into play, and no current passes through the magnet.

The circuit-breaking devices, as above remarked, are shown in my patent of July 27, 1875; but the method of running the circuits and actuating the magnets herein shown is new.

Four vibrating bars only are shown in Fig. 17, to avoid complication; but it will, of course, be understood that the bars will correspond in number with their transmitting-keys — that is to say, in the present instance, there would be thirteen in number, each bar having its own loop and local magnet. In this instance nine magnets are employed for actuating the type — three for the shifting mechanism, and one for the tripping mechanism.

In Fig. 6 the relative arrangement of the nine type-actuating magnets, 1 to 9, and the shifting-magnets, 10, 11, and 12 are clearly shown.

Having thus indicated in a general way the method of running the circuits, I will now proceed to describe the details of the receiving apparatus.

I will first describe the compound magnet C C^1, by which the vibrating bars are actuated.

In another application for Letters Patent of the United States, filed

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by me simultaneously herewith, I have shown a different method of mounting a series of vibrating bars or analyzing-receivers, each tuned to a different pitch, upon a common magnet, so that each will analyze its own tone from a series simultaneously transmitted through the single magnet. I do not, therefore, broadly claim in this application this device, except in combination with other mechanism not shown in the application above mentioned. In this instance the magnets C C^1 are mounted upon bars C^2 C^3 connecting their respective poles, and mounted in a frame, D, (see Figs. 18 and 19,) which also show a method of mounting the vibrating bars and circuit-breaking springs.

It should be observed that the bar marked 14 in Fig. 18 is inoperative in the organization hereinbefore described, having no corresponding transmitter. The bars are connected with the frame by means of insulated pins d^1 d^1, (shown in Figs. 20 and 21,) one set of pins being made adjustable, as shown in Figs 18 and 19, by set-screws, or otherwise, and admit of the proper tuning of the bars to correspond with their transmitters.

I will now proceed to describe the organization I have effected for actuating the type-shifting and type-actuating mechanism, so as to cause one lever to actuate either one of three type.

Fig 7 represents a plan view of the type-bed, showing a series of guideways or grooves radiating from a common centre, in each of which a type slides freely endwise. In the present instance the organization is such that each type successively moves to a common centre, and is struck up against a platen, to make an impression on the paper carried thereby, and is then retracted out of the way of the succeeding one, all these operations being performed automatically. In this instance the type is shown as made in the form of a bent lever, with the letter put on the end of the short arm of the lever, as moving forward radially to their working position, and then, being struck laterally to make their impression, retracting in the same way as they advanced.

The type are actuated by a vibrating shifter-lever, which I will now describe.

The details of the shifting mechanism are shown in Figs. 6, 7, 8, 9, 10, 17, and 22. In this instance the twenty-seven type shown in

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Fig, 7 are arranged in sets of three, corresponding with the respective transmitting-keys.

The operation of the type shifting and printing mechanism will readily be understood by reference to Fig. 17, which shows the three type-shifting keys 1 2 3 and a letter-key, N W. If it is desired to print the letter N, the key 1 is first depressed, thus sending vibrations to line synchronizing with the fundamental of the reed 3^a. This takes off the shunt from the corresponding loop at the point where the vibrating lever *b* comes in contact with the bar, and allows the current of the local battery to pass through the magnet 10 of the series of shifting-magnets 10, 11, and 12. A lever, E, on the armature of this magnet is thus attracted toward it and vibrates a shifter-frame, E′, upon a vertical rock-shaft, *f*, carrying a star-wheel, F, having nine arms radially slotted to correspond with each set of the type-actuating magnets 1 to 9, inclusive. On the armature of each of these magnets is mounted a rod, L, movable radially and endwise in the frame M, and carrying upon it a rocking shifter bar projecting both above and below it. The lower end of this bar slides in the corresponding slot in the star-wheel above mentioned, while its upper end moves in a path coincident with one or the other of the type-slides in which it is adapted to work, as shown in Fig. 9.

Now, when the armature-lever E is attracted, as above explained, the rocking of the shifting-frame E′ causes a partial rotation of the star-wheel, which correspondently shifts the position of the whole series of shifter-bars. In this instance the bar described would be shifted to the position shown in dotted lines, Fig. 9, marked with the letter N, which would correspond with the position of that letter in Fig. 7, and each shifter-bar would occupy the same relation to the letters included between E and N of Fig. 1. Were the shifter-bar vertical or on the letter W each shifter-bar would occupy a corresponding relation to the middle row of letters in Fig. 1, and so in regard to the outer row. This movement takes place before the type-actuating mechanism begins to operate, and, consequently, this movement is exerted upon the type or series of types previously determined by the shifting mechanism.

The armature H of the magnet 1 is connected with and actuates the slide-bar above mentioned, which carries the shifter-bar. In this

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instance, as soon as the shifting-bar is shifted in line with the type N, the armature H is attracted by the magnet 1, which forces the sliding rod L and shifter forward against the type, thus driving it forward in its groove to the central point of the machine where the impression is made. At this moment a contact-point, *i*, on the armature H, strikes a point which closes the circuit of the independent local battery and actuates a series of electro-magnets, 15, 14, and 13, the two latter operating on one armature. The attraction of the armature I by the magnet 15 throws up a printing-lever, I′, which strikes the type up against the paper carried on a platen, J, and makes the impression at the same time the magnets 13 and 14 draw down their armature K, Fig. 10, which retracts the pawl *k* operating on a spur-pinion, L, gearing into a feeding-rack, *l*, connected with the paper-carrying mechanism. As soon as the key is released at the transmitting-station the circuit is shunted, thus releasing the type-actuating armature of the magnet 1, and breaking the circuit of the printing and paper-feeding magnets 13, 14, and 15, which allows the type to drop and be retracted by its spring M′ to its normal position. A spring, *k*′, then retracts the armature K of the magnets 13 and 14, forcing the pawl forward and actuating the feed-bar and moving the paper-carrying mechanism forward a distance sufficient to afford space for the next letter, in a manner similar to an ordinary writer. This process is repeated with each successive letter.

When the paper-carrying mechanism has been fed along a distance equal to the length of the line which the machine is adjusted to print, the feed-carriage N strikes a lug, *o*, on a sliding bar, O, and moves it endwise in its frame until its point *o*′ comes in contact with a spring, *p*, which closes the local battery of the magnet 16. This draws down an armature mounted on a lever, R, rocking on a pivot, *r*, and carrying the gear-wheel above mentioned, which actuates the feed-bar. The drawing down of the armature lifts this gear out of contact with the feed-bar, and the paper-carrying mechanism is immediately retracted by the spring F′. The platen in this instance consists of a roller around which the paper passes, which roller rotates in bearings in the sliding carriage. During its forward movement the platen is prevented from rotating by means of a series of pins, *s*, on a wheel, S, on the same axis as the platen, which pins

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pass on each side of a guide-bar, S′. On the backward movement of the sliding carriage, however, one of these pins strikes against a pivoted spring-switch, *t*, under the guide-bar, which deflects the pins and turns the platen a distance equal to that desired for the distance between the rows of type. On the next forward movement of the feeding-carriage the point of the spring-switch yields to allow the pin to pass without turning the platen, and as soon as the pins pass the point of the switch it is thrown open again by a spring in readiness for the next backward movement of the carriage after the printing of the line is completed.

The carriage can be thrown back at any desired point in the line by pressing the trip-key of the transmitter, which, through a corresponding analyzing-spring in the receiver, throws the local circuit into connection with the magnet 16 in the same manner as that described as taking place by the operation of the sliding bar, thus releasing the sliding carriage and allowing it to return to its starting-point.

It will thus be observed that the operator at the transmitting-station is not only enabled to print at the receiving-station any letter desired, and automatically to shift the paper to commence a new line, type-writer fashion, but he is also enabled to shift the sliding carriage at the receiving-station at will by means of his trip-key to commence a new line.

I propose to employ a ribbon fed between the paper and type by well-known mechanical means, such as commonly used in type-writers, which, to avoid complication, is not shown in the drawings, and which needs no description.

I contemplate using a web or long strip of paper, so as to dispense with the constant watching of the receiving instrument by the attendant, and by means of the trip-key above mentioned the paper can be fed along so as to leave a space between each message to permit of their being separated and delivered without rewriting.

I am thus enabled by my invention not only to print a telegraph message without the use of a type-wheel, and without the use of synchronously-moving step-by-step (or steadily-revolving) mechanism, such as has heretofore been universally employed, so far as my knowledge extends, and thus save the time necessary for the type to

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come into position, the operator's ability to transmit being thus, by my invention, the only limit to the speed of the apparatus.

I am also enabled by my invention to print messages in the form of a page or letter-sheet in contradistinction to printing it in a single line and on a narrow strip as heretofore has been the case.

I am further enabled to determine in advance, by the transmission of one tone, which one of a series of type shall move to make its impression, by throwing it into connection with mechanism actuated by the tone appropriated to the particular type to be printed.

I claim as my invention —

1. The hereinbefore described art of electro-harmonic telegraph-printing, which consists in printing each letter at the receiving-station by the direct and instantaneous action of a local battery controlled by a key at the transmitting-station corresponding with said letter.

2. The hereinbefore-described art of electro harmonic telegraph-printing, which consists in printing a message on a letter-sheet, type-writer fashion, by the direct operation of keys at the transmitting-station controlling local batteries actuating the printing mechanism.

3. The hereinbefore-described art of electro-harmonic telegraph-printing, which consists in transmitting tones of different pitch through an electric circuit by means of corresponding keys, and reproducing said tones at the receiving station as a means of actuating local batteries controlling printing mechanism, which prints a letter corresponding with that of the key controlling the particular tone which throws the local battery into operation.

4. The hereinbefore-described art of electro harmonic telegraph-printing, which consists in determining in advance, through the action of one local battery, which one of a series of letters, numbers, or characters shall be printed by mechanism actuated by another local battery.

5. The improved art of electro-harmonic telegraph-printing, which consists in determining in advance, by means of one local battery, the point at which the printing of the message, by another local battery, shall begin.

6. The hereinbefore-described art of electro-harmonic telegraph-printing, which consists in throwing forward a particular type to be printed by one local battery, and making an impression by that par-

ticular type by another local battery automatically thrown into action by the movement of the type.

7. The hereinbefore-described art of electro-harmonic telegraph-printing, which consists in feeding forward the paper upon which the message is printed by mechanism thrown into operation by a local battery controlled by the printing of the preceding letter.

8. The hereinbefore-described art of electro-harmonic telegraph-printing, which consists in touching a key which transmits a particular tone, by which one local battery determines in advance what particular letter shall be printed; carries forward the type selected, which, in turn, actuates another local battery which makes the impression and controls the feeding mechanism.

9. The combination, substantially as hereinbefore set forth, of a reciprocating type moved in one direction by the armature of the electro-magnet, and in the other by a spring.

10. The combination, substantially as hereinbefore set forth, of the armature of the magnet, the endwise-moving frame, the type pivoted thereon, and the retracting-spring attached directly to the type.

11. The combination, substantially as hereinbefore set forth, of a series of type, movable radially relatively to a common center, a shipper acting upon one of the series, and a series of electro-magnets, which control the action of the shipper.

12. The combination, substantially as hereinbefore set forth, of a series of type, a carrier or shifter bar acting upon either one of said type, a series of electro-magnets which control the selection of the type to be acted upon, and a second electro-magnet which actuates the type selected.

13. The combination, substantially as hereinbefore set forth, of a series of type, a shifting carrier acting upon one of the types of the series, a series of electro-magnets which select the type to be acted upon, a second electro-magnet which actuates the type selected, and a third electro-magnet which actuates the printing-hammer, to make an impression of the selected type.

14. The combination, substantially as hereinbefore set forth, of an electro-magnet for actuating the printer-hammer, and an electro-magnet for actuating the paper-feeding mechanism.

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15. The combination, substantially as hereinbefore set forth, in an electric circuit, of a vibrating reed producing a musical tone, or a definite number of vibrations per unit of time, a key controlling said vibrations, a corresponding reed at the receiving end of the line, a local battery controlled by said vibrating reed or circuit-breaker, and an electro-magnet, the armature of which carries a type, for the purpose specified.

16. The combination, substantially as hereinbefore set forth, in an electric circuit, of a series of circuit-breakers capable of producing tones of different pitch, a series of corresponding receivers, a series of keys controlling the transmission of said tones, a series of local batteries controlled by the vibrating receivers, and a series of type controlled directly by the electro-magnets of the local batteries.

17. The combination, substantially as hereinbefore set forth, in an electric circuit, of a series of transmitting keys, printing mechanism controlled by said keys, and a shifting-key for determining in advance which letter of a series, marked on each key, shall be printed.

18. The combination, substantially as hereinbefore set forth, in an electric circuit, of printing mechanism, keys controlling said printing mechanism, and a trip-key, which determines the point at which the printing of the message begins.

19. The combination, substantially as hereinbefore set forth, in in an electric circuit, of printing mechanism, keys for controlling the printing mechanism, keys for determining which one of a series of type shall be printed, and a trip-key which determines the point on the paper at which the printing shall begin.

20. The combination in an electric circuit, substantially as hereinbefore set forth, of apparatus for transmitting tones of different pitch, keys controlling said apparatus, receivers which analyze and reproduce said tones, and independently-movable type, each controlled by its particular tone.

21. The combination, substantially as hereinbefore set forth, of a paper-carrier, a spring for moving it in one direction, a feed-bar, and a gear-wheel mounted on the armature of the electro-magnet, and adapted to be thrown into or out of gear with the feed-bar by the movement of the armature.

22. The combination of the paper-carrying mechanism, a feed-

bar, a gear-wheel actuating said bar mounted on the armature of one electro-magnet, and a feed-pawl mounted on the armature of another electro-magnet.

23. The analyzing-receiver hereinbefore described, consisting of the combination of two or more magnets, with their light poles united by connecting-bars, constituting, in fact, one magnet, and a series of tuned receiving-springs vibrating near said bars, so that each shall receive its proper tone from said magnet.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. A. SKINKLE,

WM. J. PEYTON.

DEFENDANT'S EXHIBIT GRAY'S CLOSED CIRCUIT PATENT.

(INTRODUCED RECORD, PAGE 67.)

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY, OF NEW YORK CITY.

IMPROVEMENT IN ELECTRO-HARMONIC TELEGRAPHS.

Specification forming part of Letters Patent, No. 186,340, dated January 16, 1877; application filed January 27, 1876.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented a new and useful improvement in the art of transmitting and analyzing musical impressions or sounds, and in apparatus for so transmitting and analyzing such sounds, of which the following is a specification:

My invention more especially relates to an electro-harmonic system of multiple telegraphy heretofore invented by me, and secured by sundry Letters Patent of the United States, in which composite musical tones are transmitted through a single wire, and analyzed or separated at the receiving end of the line by vibrating reeds, bars or

strings, tuned correspondingly with the respective transmitters of the composite tones.

In an application for Letters Patent of the United States filed by me February 23, 1875, for transmitting musical vibrations by electricity, I have shown not only the various devices for transmitting or receiving the musical impressions; but also one method of arranging the electric circuit for producing the desired result, including the relation of the main battery to the line and instruments at both ends, and described the effects produced.

In my prior patents and application, above mentioned, the full force of the battery was at all times exerted upon the line; that is to say, when one transmitter was employed, and the others were at rest, it worked with the full force of the whole main battery, and when all the transmitters were employed, the same force was necessarily divided among them; consequently the amplitude of the vibrations of any given tone would diminish or increase, according to the number of tones simultaneously sent to line, thus rendering analysis at the receiving end of the line more difficult.

My present improvement contemplates the avoidance of this objection, by insuring the transmission of tones of uniform amplitude of wave, whether a greater or less number of tones be transmitted simultaneously, which end I attain by combining each transmitter with its respective section of the main battery, by a short or shunt circuit, in such manner that each section is utilized for the transmission of the vibrations for its own tone, without interfering or drawing upon the other section of the battery, or opening the main circuit, and when not transmitting the unemployed sections of the battery flow steadily to line, without affecting the working transmitters of the other sections.

My improvement thus possesses two distinguishing characteristics: first, that of a main circuit always closed; and, second, the passage through this circuit of a smooth current, so to speak, when all the transmitters are quiescent, each transmitter when in operation throwing its respective portion of said current into vibration, so that there may be a smooth current, and one or more vibratory waves simultaneously transmitted through the circuit, or the entire current may be thrown into vibration.

The subject-matter claimed hereinafter will specifically be designated.

The accompanying drawings represent a perspective diagram of so much of my approved apparatus as is necessary to illustrate the subject-matter claimed.

I have shown this apparatus as constructed in the best way now known to me; but it is obvious that the details of construction of its various parts may be varied within certain limits, in ways well known to skillful electricians.

I have shown three transmitters with their batteries, and corresponding receivers at each end of the line, so arranged as to transmit three messages each way simultaneously; but a greater or less number of transmitters and receivers may be employed, and they might be so arranged as all to transmit one way instead of in opposite directions.

It is deemed unnecessary to describe in detail here the construction of the battery, as it forms no part of the subject-matter claimed, and any of the well-known batteries of the present day will work effectively with my improved apparatus.

The construction of the transmitters and receivers is fully set forth and described in my Letters Patent and application above-mentioned, and needs no reiteration here.

Each battery is connected with its respective transmitter by a short circuit or shunt wire. Starting with battery No. 1, G is the ground-wire connected at the plus (+) pole of the battery, which battery is connected up in the ordinary way and runs to line at the other or minus (—) end, through the analyzing-receivers F′ E′ D′. The line connects at the other end through the analyzing-receivers C′ B′ A′ to the plus (+) pole of battery No. 2, and passes through in the ordinary way to the ground-wire G′ at the minus (—) pole of said battery.

The circuit, thus far, is similar to an ordinary Morse circuit closed, and without a key or other means of making or breaking the circuit.

A B C D E F represent six sets of transmitters, each set being composed of a common open circuit, Morse telegraphic key, and a musical-tone transmitter, such, for instance, as that described in Letters Patent No. 165,728, granted to me July 20, 1875, for improvement in transmitters for electro-harmonic telegraphs. These trans-

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mitters are all alike in construction, but each one is tuned to a different pitch, and has a receiver, A′ B′ C′ D′ E′ F′, correspondently tuned, at the other end of the line.

Each battery is divided into sections 1 2 3 4 5 6, not by separating or disconnecting its cells, but by throwing a short circuit or shunt wire around each section. For instance, the first short circuit of battery 1 consists of the wires *a b*, the second of the wires *b c*, and the third of the wires *c c′*, and so on. The number of cells in each section is determined by the distance the tone is to be transmitted.

Each shunt-wire runs through its own key and vibrating transmitter. For instance, in section 1 of battery 1, which is at the line end of the battery, a wire, *a*, passes from the minus (—) pole of the battery to one binding-screw of the transmitter A, at which point the circuit divides, one branch connecting to line L, and the other to the vibrating bar of the transmitter through the break-point, which is in this instance a shunting-point. The circuit then passes to the other binding-screw, and thence to the key-lever.

The anvil or lower point of the key is connected directly with the ends of the wire *b*, which forms the dividing-line between sections 1 and 2, forming part of the short circuit of each section, and so on. Now, if the reed or bar of transmitter A be vibrated by its local battery, (which is omitted from the drawing to avoid complication, but the operation of which is well understood,) and the key belonging to it and in the same circuit with it be depressed, the shunt-circuit around section 1 will be completed every time the vibrating bar or reed makes contact with its break-point, thus producing a set of waves or electrical vibrations throughout the line, the waves succeeding each other at the rate per second corresponding to the vibrations of the transmitting reed or bar, which waves will induce corresponding impulses in all the magnets of a power approximating one-sixth of the whole battery.

Although these magnetic impulses are induced in all the magnets in the circuit, one only will make an audible response, except to a very delicate test, which one, in this instance, will be the receiver marked A′, as one whose reed or ribbon (or reed and box, as the case may be) is tuned correspondently to the transmitter in operation. All the other sections of the apparatus are connected up and operated in

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a manner precisely similar, each operating on its own section of battery. Each transmitter differs in pitch from every other one, and has its complement in its corresponding receiver.

It will be observed that by working with this improved system the main circuit is never opened, owing to which fact the integrity of each set of waves is preserved intact, thus rendering analysis easy at the receiving end of the line.

The utility of the device has been amply demonstrated by practical operation.

I claim as of my own invention —

1. The improvement in the art of telegraphically transmitting composite tones, hereinbefore set forth, which consists in working a closed circuit with a continuous current from a main battery, portions of the whole of which current are thrown into vibration at will by the transmitters.

2. The improvement in the art of telegraphically transmitting and analyzing composite tones, hereinbefore set forth, which consists in working a closed circuit with a continuous current from a main battery, portions of the whole of which current are thrown into vibration at will by the transmitters, each set of vibrations being audibly reproduced by a corresponding receiver.

3. The combination, substantially as hereinbefore set forth, of a series of transmitters, each operated by a local battery, a main battery, an electric circuit, through which a continuous current flows from said battery, and shunt or short circuits between the main battery and transmitters.

4. The combination, substantially as hereinbefore set forth, of a series of transmitters, a main battery connected therewith by short or shunt circuits, a closed electric circuit, through which a current continuously passes from the main battery, and a series of analyzing-receivers, included in the circuit.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON,
JOSEPH S. PEYTON.

3785

DEFENDANT'S EXHIBIT GRAY DOUBLE BAR MAGNET PATENT.

[INTRODUCED RECORD, PAGE 68.]

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY, OF NEW YORK CITY.

IMPROVEMENT IN RECEIVERS FOR ELECTRO-HARMONIC TELEGRAPHS.

Specification forming part of Letters Patent, No. 198,379, dated December 18, 1877; application filed April 12, 1876.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Receivers for Electro-Harmonic Telegraphs, of which the following is a specification: —

My invention relates to an analyzing-receiver having two or more analyzing springs or bars, combined with a single electro-magnet, and constitutes an improvement upon the instrument shown in Letters Patent No. 166,094, granted to me July 27, 1875; the improvement consisting in combining two or more analyzing springs or ribbons, with separate adjustment, with the magnet, instead of the single bar or ribbon shown in that patent.

In the accompanying drawings, Figure 1 represents a plan or top view of my improved apparatus; Fig. 2, a side elevation thereof; and Fig. 3, a vertical transverse section therethrough on the line 1 1 of Fig. 1.

In this instance, A represents a suitable base-board; B, B^1, B^2, B^3, B^4, suitable binding screws for the electrical connections; C, a triangular frame, upon which an electro-magnet, D, is mounted; E, E′, two ribbons or springs, provided with tension-screws *e*, *e*′, by which they may be adjusted; and F, F′, two circuit-breaking springs, adapted to vibrate more slowly than the bars E, E′, and provided with mechanism to adjust their rate of vibration.

3786

E. GRAY.

Receiver for Electro-Harmonic Telegraphs.

No. 198,379. Patented Dec. 18, 1877.

Fig 1

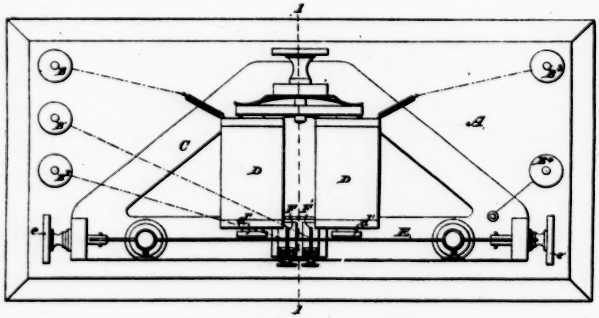


Fig 2

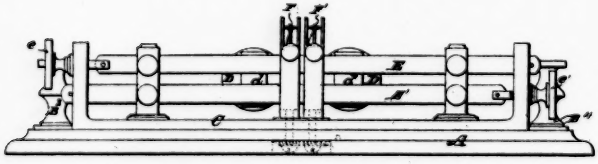
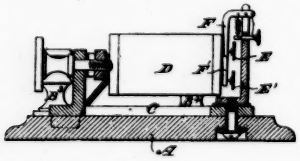


Fig 3.



WITNESSES

Wm A Skinkle
L Stith

By his Attorney

INVENTOR

Elisha Gray

Wm. Baldwin

3787

The ends of the magnets are provided with pole pieces *d*, *d'*, which extend opposite the springs, so that two or more of these springs or analyzing-receivers may be included within the attraction of the same magnet.

When two notes of different pitch are transmitted through the electric circuit simultaneously, and the two receiving-springs are tuned in unison with their respective transmitters, each will respond to its respective tone; but if either note is stopped, its corresponding receiver ceases to vibrate, just as if operated by a separate magnet, the reasons of which operation will be obvious upon consideration of the fact that the cores of all the magnets in the circuit respond to all the electric impulses sent through them, whether simple or complex, the analyzing principle being developed only by the appliances upon which the magnetic impulses act. From this it is obvious that one or more magnet would operate two or more tuned reeds or bars, mounted, in order to secure amplification of sound, upon resonant boxes, such as shown in my application for Letters Patent filed Jan. 8, 1876.

The advantages of this apparatus are not only in the direction of economy of saving in a number of magnets, but of battery-power, as it is well known that the induction of a great number of electro-magnets in a telegraph-line seriously diminishes the working power of the battery.

In an application for Letters Patent filed simultaneously herewith I have shown and described this apparatus, as carried out on a large scale, in combination with a printing telegraph.

I claim as of my own invention, —

The combination, substantially as hereinbefore set forth, in an electric circuit, of an electro-magnet through which notes of different pitch are transmitted with two or more vibrating receiving-springs, tuned correspondingly with the notes so transmitted, whereby each analyzer selects its own tone from the magnet without interfering with the others.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. A. SKINKLE,

W. J. PEYTON.

3788

DEFENDANT'S EXHIBIT GRAY'S COMMON RECEIVER PATENT.

[INTRODUCED RECORD, PAGE 67.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN THE ART OF TRANSMITTING RHYTHMICAL VIBRATIONS IN AN ELECTRIC CIRCUIT.

Specification forming part of Letters Patent, No. 205,378, dated June 25, 1878; application filed April 9, 1878.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful improvements in the art of generating and transmitting through an electric circuit rhythmical impulses, undulations, vibrations, or waves, representing composite tones, musical impressions or sounds of any character or quality whatever, and of audibly reproducing such vibrations; and also in apparatus for so generating, transmitting and reproducing such impulses, undulations, vibrations, or waves, of which improvements the following is a specification:

In Letters Patent of the United States Nos. 166,095 and 166,096, granted to me July 27, 1875, in the caveat filed by me February 14, 1876, and in sundry applications for Letters Patent for improvements in electric telephony filed October 29, 1877, I have shown devices intended to operate as common receivers and reproducers of all sorts of rhythmical vibrations representing sounds of whatever kind or quality with reference to the number of tones simultaneously transmitted, received, and reproduced, and their relations to each other in respect to amplitude, rate, &c.

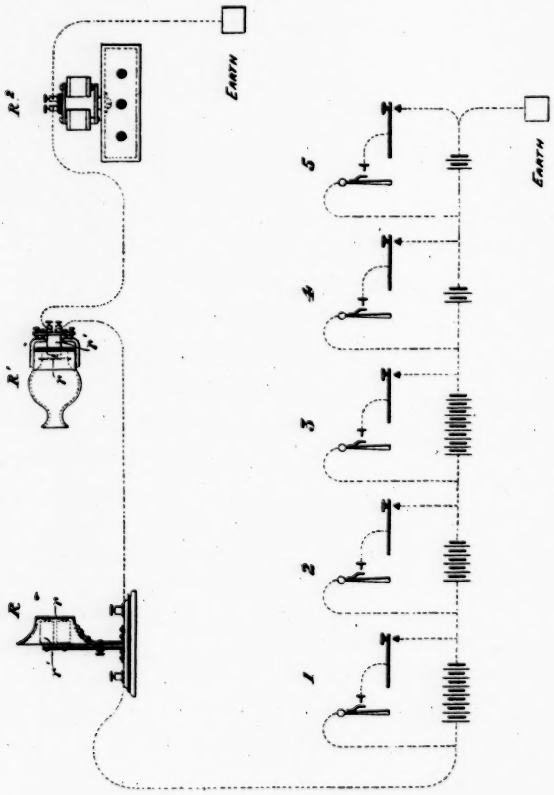
In an application for Letters Patent filed by me Feb. 23, 1875, for improvements in the art of transmitting musical impressions or sounds telegraphically, and in apparatus for so transmitting such sounds, or impressions, I have shown devices for transmitting musical sounds, and one method of arranging the same on an electric circuit to produce the desired results, including the relation of the main battery to the line and instruments at each end, and described the effects produced.

3789

E. GRAY.

Art of Transmitting Rhythmical Vibrations in an Electric Circuit

No. 205,378. Patented June 25, 1878.



WITNESSES

Wm A Skinkle

Geo. W Beck.

INVENTOR

Elisha Gray.

By his Attorneys

Baldwin Hopkins & Peyton

3740

In Letters Patent No. 186,340, granted to me Jan. 16, 1877, I have shown and described a method of and apparatus for generating, transmitting, and reproducing in an electric circuit rhythmical impulses, undulations, vibrations, or waves, as well as an improved method of connecting the transmitting apparatus to the line and main battery, so that any tone of a series could be transmitted without interference with the power used for transmission of another tone, and so that two or any greater number of tones could simultaneously be transmitted, received, and reproduced, preserving their individuality as perfectly as the same would be preserved in passing through the air. This patent also showed a closed circuit, in which a continuous current from a main battery kept a reproducing and receiving magnet constantly charged, and devices for varying the power or electro-motive force of the current by superposing thereupon the vibrations or undulations generated by the transmitters.

In Letters Patent No. 175,971, granted to me April 11, 1876, for improvements in telephonic telegraph apparatus, I have shown a series of receivers so constructed that each receiver, which consists of a resonant box with a magnet having a tuned armature mounted upon it, will only respond to the particular note to which it is adapted, this apparatus, in practice, being arranged upon circuit as shown in my patent of Jan. 16, 1877, No. 186,340, above mentioned.

By having a number of receivers tuned to all rates of vibration, with correspondently-tuned transmitters, it is possible to transmit and receive composite sounds varying greatly in respect to quality, rate, &c. For instance, the different vowel sounds may be transmitted and received by this apparatus, providing that the receivers are of the proper relation to each other, and all arranged near together, so as to get the composite effect of the tone sent through the wire.

Such an apparatus constitutes the subject-matter of a division of this application, filed May 18, 1878.

To render the vowel sound A, for instance, I would transmit a composite tone, the simple elements of which would bear the following relations to each other. The amplitude of vibration of any simple tone which goes to make up the composition of a vowel or any sound is determined in this case by the number of cells of the battery used by the transmitter of that particular tone. Let us

3791

assume as a basis for the fundamental or lowest tone in the clang or composition of tones one hundred vibrations per second. The vowel A is composed of five simple tones. If, as we have assumed, the first or fundamental tone have one hundred vibrations per second the second tone will have two hundred, the third three hundred, the fourth four hundred, and the fifth five hundred. These tones, however, to produce the desired effect, must not all have the same amplitude or loudness; the second tone should be rather moderate in strength, which will be accomplished by giving it fewer cells of battery; the third, much greater amplitude, as this is the characteristic note of the clang, to accomplish which we add a greater number of cells of battery; while the fourth and fifth are added with a feeble amplitude. It will be seen that by this arrangement we are able to control not only the number of tones transmitted, but their relations with respect to rate and amplitude.

My present invention constitutes an improvement upon the invention set forth in the patents and applications above recited, and contemplates the combination, in an apparatus for generating and transmitting vibrations, impulses, or waves representing composite tones of a closed circuit, a series of transmitters vibrating at such relative speeds as to produce the fundamental and harmonics of the tone to be transmitted, a main battery so arranged as to give each transmitter the desired relative amplitude of vibration, and a common receiver, or one capable of reproducing tones of every variety and quality.

The subject-matter claimed will hereinafter specifically be designated.

The accompanying diagram represents an arrangement upon circuit of generating, transmitting, and reproducing apparatus for carrying out my improvement, three different varieties of common receivers or reproducers being shown.

The different sections, 1, 2, 3, 4, 5, of the main battery, it will be observed, are arranged, as to number of cells or electro-motive force, with respect to the amplitude of vibration or wave desired in each of the tones of the composition.

The diagram shows three different kinds of receivers, R, R^1, R^2, each capable of reproducing composite tones or sounds of every

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character. It is deemed unnecessary to describe in detail the construction of the apparatus employed, more than to say that it comprises main and local batteries, an apparatus for generating and transmitting vibrations representing the composite tone to be transmitted, a receiving apparatus capable of reproducing such tones, and a closed circuit through which a continuous current flows to keep the magnets permanently charged. The arrangement of circuit is similar to that shown in my patent of Jan. 16, 1877, above mentioned, while the transmitters represented in the diagram are similar to those shown in Letters Patent No. 165,728, granted to me July 20, 1875. Each transmitter is operated by its respective local battery, omitted for convenience of representation. The receivers R, R^1 are similar to those shown in sundry applications for Letters Patent of the United States filed by me Oct. 29, 1877, and consist (speaking generally) of a diaphragm, *r*, adjustably arranged relatively to an electro-magnet, *r'*. The receiver R^2 consists of an electro-magnet mounted upon a sounding-box in a way that will be readily understood from the drawings, and (like the others) is capable of reproducing tones of all varieties and qualities.

It will be observed that my arrangement of batteries and transmitters admits of an unlimited variety of adaptations and combinations in respect to number and character of tones as to amplitude, rate, &c., so that when the quality of any tone is once determined by analysis it may be reproduced by my combination by the organization of the several parts relatively to each other.

The operation of my invention will readily be understood from the accompanying description. When it is desired to transmit a composite tone of a particular clang, I depress the keys which bring into operation such batteries and transmitters as an analysis of such clang dictates we should use. To transmit a sound of different quality, depress a different set of keys, arranged, as before stated, with reference to the necessities of the case.

It is unnecessary to go into a detailed analysis of a great variety of sounds, as the principle involved is fully set forth in the case already given.

From the above it is easy to conceive that composite tones may

be mechanically transmitted by a proper arrangement of transmitters, batteries, &c.

What I claim as of my own invention, and desire to secure by Letters Patent, is —

The combination, substantially as hereinbefore set forth, in an apparatus for generating and transmitting vibrations, impulses, or waves representing composite tones, of a closed circuit, a series of transmitters vibrating at such relative speeds as to produce the fundamental and harmonics of the tone to be transmitted, a main battery so arranged as to give each transmitter the desired relative amplitude of vibration, and a common receiver, or one capable of reproducing tones of every variety and quality.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

GEO. B. CUMMINGS,

D. M. ERSKIN, Jr.

DEFENDANT'S EXHIBIT GRAY'S REVOLVING DRUM TELEPHONE PATENT.

[INTRODUCED RECORD, PAGE 73.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN SPEAKING-TELEPHONE.

Specification forming part of Letters Patent No. 210,776, dated December 10, 1878; application filed August 8, 1878.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Speaking Telephones, of which the following is a specification:

In Letters Patent No. 166,096, granted to me July 27, 1875, on an application originally filed April 18, 1874, I have shown and described apparatus for transmitting rhythmical vibrations represent-

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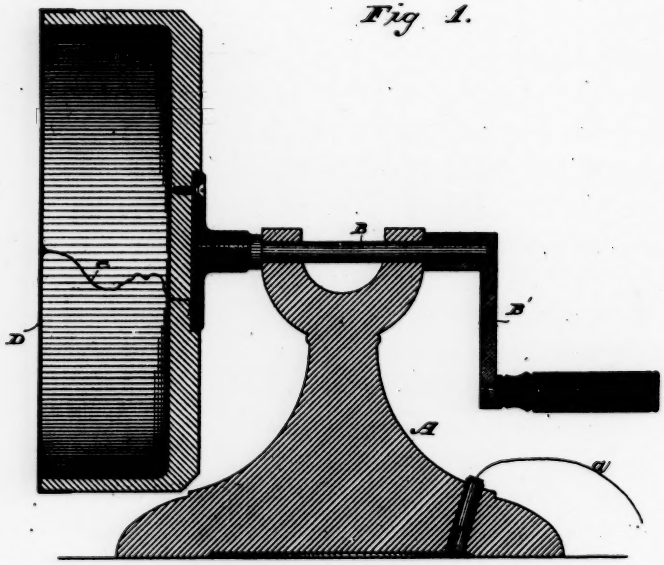
2 Sheets—Sheet 1.

E. GRAY.

Speaking-Telephone.

No. 210,776. Patented Dec. 10, 1878.

Fig. 1.



WITNESSES

Geo W Buck

Wm A Skinkle

INVENTOR

Elisha Gray.

By his Attorneys

Baldwin, Hopkins & Peyton

3745

2 Sheets—Sheet 2.

E. GRAY.

Speaking-Telephone.

No. 210,776. Patented Dec. 10, 1878.

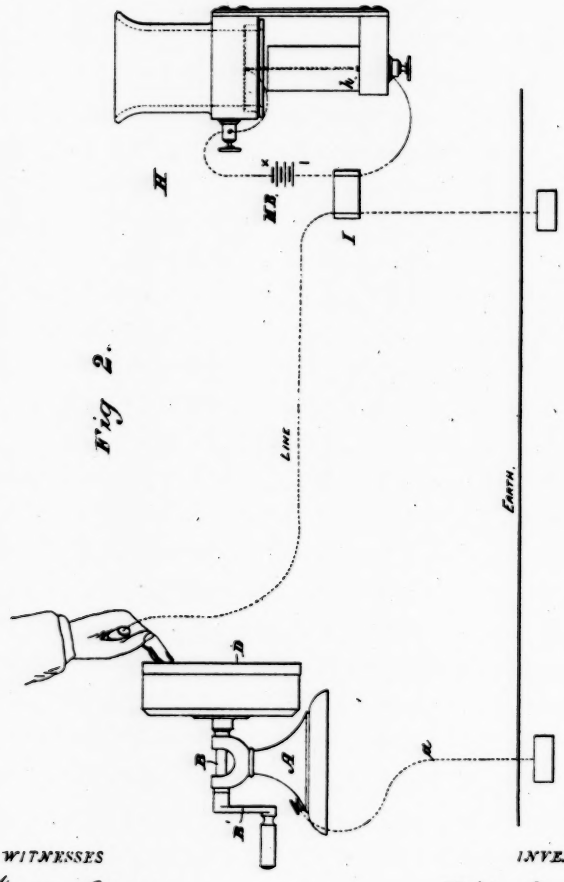


Fig 2.

WITNESSES

Wm A Grindle

Geo H Buck

INVENTOR

Elisha Gray

By his Attorneys

Baldwin Hopkins & Peyton

3796

ing composite sounds or musical tones of different pitch telegraphically, and for reproducing said tones at the receiving end of the line through the medium of animal tissue.

My present invention constitutes a new application of the principle exemplified in said Letters Patent, its object being to reproduce articulate sounds at the receiving end of the telegraphic circuit through animal tissue in gliding contact with a plate of suitable metal.

Any of the well-known speaking-telephones which transmit with sufficient intensity may be employed as a transmitter, in my improved apparatus. I prefer, however, for a transmitter the one known as the "water-telephone," described in a pending application for Letters Patent filed by me October 29, 1877, or the Edison carbon telephone transmitter, or some instrument used in connection with a battery, on account of the greater power which may be obtained from such a transmitter.

I prefer to use currents of considerable tension in working my improved apparatus, the most convenient and economical mode of doing which is by the use of an induction-coil, as shown and described in my Letters Patent above mentioned.

The receiving apparatus is substantially the same in construction and operation as the one heretofore employed by me for reproducing musical tones transmitted through a telegraphic circuit.

My invention therefore consists in combining, in an electric circuit, telephonic apparatus capable of transmitting articulate speech with a resonant receiver through the intervention of animal tissue in gliding or frictional contact with said resonant receiver. This receiver may consist of a plate of any of the well-known metals, whether capable of induction or not. I prefer, however, to use a plate, disk, or diaphragm of thin sheet metal — such as zinc or German silver, highly polished, and oxidized on the surface exposed to friction. The frictional or gliding contact between the animal tissue and the receiving-plate may be produced in various ways; but I have found in practice the simplest and most effective to be to mount the receiving-plate upon a resonant box or case mounted upon a shaft, so as readily to be revolved by means of a pulley, crank,

treadle, or other well-known motor. By this means an even pressure and uniform rotation of the receiving-plate is secured.

The animal tissue may consist of one or more fingers of the human hand interposed in the circuit and pressed against the plate. Various other equivalent substances are mentioned in my patent above mentioned.

The accompanying drawings show one convenient form of apparatus for carrying out the objects of my invention. Obviously, however, the details of construction of both the transmitter and receiver may be greatly varied without departing from the spirit of my invention.

Figure 1 represents an axial transverse section through the receiver; and Fig. 2 represents an arrangement upon circuit of the entire apparatus, including both transmitter and receiver.

The base or supporting-stand A is, by preference, made of metal, and of a weight and size sufficient to maintain it in position without fastening it to its support. A shaft, B, revolves in suitable bearings upon this stand, being driven by a crank, B′, or by a pulley, clock-work, or other suitable prime mover, and carries a hollow resonant box or case of wood, or some other resonant substance. The outer or open end of this box is covered by a thin sheet-metal disk, plate, or diaphragm, D, preferably of zinc, as the surface of this metal is usually covered with a very thin film of oxide, which is highly favorable to the proper action between the animal tissue and the plate when in gliding contact.

The diaphragm, it will be observed, is connected with the shaft and base by a wire, *e*, inside the resonant box or case, the base being in turn connected with the ground by a wire, *a*. The transmitter H in this instance is an ordinary speaking telephone, of the form shown in my application filed October 29, 1877, above mentioned, known as a "variable-resistance telephone," which class includes the microphone, the carbon transmitter, the water transmitter, and all others of that class which produce the sound-waves by causing the vibrations of the diaphragm to vary the resistance of the battery-current proportionately to the amplitude of motion of said diaphragm. I do not, however, confine myself to a transmitter of

this class, but contemplate using any form which will transmit the vibrations with sufficient force.

The main battery M B is shown in Fig. 2 as short-circuited through the transmitter and through the induction-coil I, having the usual primary and secondary circuits in such relation to each other as will produce the best results at the receiving end of the line.

Starting from the plus pole of the battery, the circuit passes through the transmitter-point *h*, thence through the primary helix of the induction-coil and back to the other pole of the battery. The secondary helix has one of its poles connected to the line, the other with the ground. At the receiving end of the line the circuit passes through animal tissue, which may consist of the human body or other equivalent material, which is in contact with the plate D, from whence the circuit passes to the ground through the stand, as shown in Fig. 2, and as hereinbefore described.

The induction-coil may be dispensed with by using a battery of high tension and small quantity; but this method would not be so economical in practice as the one hereinbefore described.

In my patent of July 27, 1875, hereinbefore mentioned, I have shown that rhythmical vibrations in a primary circuit corresponding to any given musical tone or any given number of tones simultaneously produced are correspondingly produced inductively in a secondary circuit, and that when these vibrations were passed through animal tissue, in contact with a receiver, such as described, the tones were audibly and accurately reproduced.

My present invention contemplates not only the production of musical tones, but sounds of every character and quality, so that any noise, whether consisting of spoken words, musical tones, or other sounds, made or uttered in the transmitter or in its immediate vicinity, would be reproduced audibly at the receiving end of the line on the revolving plate.

I do not, therefore, claim the use of an animal-tissue receiver for the reproduction of musical tones, in combination with a transmitter only adapted to send such tones, as this constitutes the subject-matter of the patent hereinbefore mentioned.

What I claim herein as new, and desire to secure by Letters Patent, is—

3799

The combination, in a telegraphic circuit, of a telephonic transmitter capable of transmitting articulate sounds or spoken words with a receiver capable of reproducing such sounds or words through the intervention of animal tissue in frictional contact with said receiver.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

JOHN F. PARET,

DAVID M. ERSKINE, Jr.

DEFENDANT'S EXHIBIT B.

DEFENDANT'S EXHIBIT GRAY'S CAVEAT. 2.

[INTRODUCED RECORD, PAGES 37, 67.]

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come. Greeting:

This is to certify that the annexed is a true copy from files of this office of the Caveat of Elisha Gray, filed Feb. 14, 1876, for "Art of Transmitting Vocal Sounds Telegraphically."

In testimony whereof, I, W. H. Doolittle, Acting Commissioner of Patents, have caused the seal of the Patent Office [SEAL] to be hereunto affixed this twenty-eighth day of March, in the year of our Lord one thousand eight hundred and seventy-eight, and of the Independence of the United States the one hundred and second.

W. H. DOOLITTLE,

Acting Commissioner.

UNITED STATES PATENT OFFICE.

SPECIFICATION.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook, and State of Illinois, have invented a new Art of Trans-

3800

ELISHA GRAY

INSTRUMENTS FOR TRANSMITTING AND RECEIVING VOCAL SOUNDS TELEGRAPHICALLY.

CAVEAT FILED FEBRUARY 14TH 1876.

Fig 1.

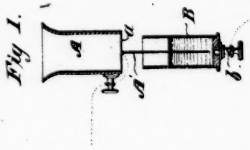


Fig 3.

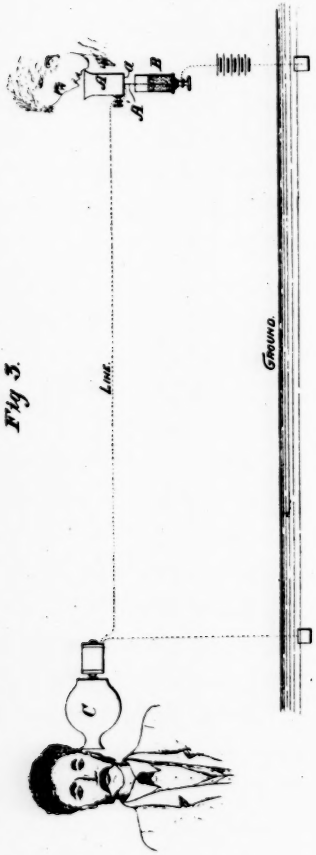


Fig 2

WITNESSES

Wm A Skinkle

F. Sieh

INVENTOR

Elisha Gray

mitting Vocal Sounds Telegraphically, of which the following is a specification.

It is the object of my invention to transmit the tones of the human voice through a telegraphic circuit, and reproduce them at the receiving end of the line, so that actual conversations can be carried on by persons at long distances apart.

I have invented and patented methods of transmitting musical impressions or sounds telegraphically, and my present invention is based upon a modification of the principle of said invention, which is set forth and described in Letters-Patent of the United States, granted to me July 27, 1875, respectively numbered 166,095, and 166,096, and also in an application for Letters-Patent of the United States, filed by me, February 23, 1875.

To attain the objects of my invention, I devised an instrument capable of vibrating responsively to all the tones of the human voice, and by which they are rendered audible.

In the accompanying drawings I have shown an apparatus embodying my improvements in the best way now known to me, but I contemplate various other applications, and also changes in the details of construction of the apparatus, some of which would obviously suggest themselves to a skilful electrician, or a person versed in the science of acoustics, on seeing this application.

Figure 1 represents a vertical central section through the transmitting instrument;

Figure 2 a similar section through the receiver; and

Figure 3 a diagram representing the whole apparatus.

My present belief is, that the most effective method of providing an apparatus capable of responding to the various tones of the human voice, is a tympanum, drum or diaphragm, stretched across one end of the chamber, carrying an apparatus for producing fluctuations in the potential of the electric current, and consequently varying in its power.

In the drawings, the person transmitting sounds, is shown as talking into a box, or chamber, A, across the outer end of which is stretched a diaphragm *a*, of some thin substance, such as parchment or gold-beaters' skin, capable of responding to all the vibrations of the human voice, whether simple or complex. Attached to this diaphragm is a light metal rod A′, or other suitable conductor of

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electricity, which extends into a vessel B, made of glass or other insulating material, having its lower end closed by a plug, which may be of metal, or through which passes a conductor *b*, forming part of the circuit.

This vessel is filled with some liquid possessing high resistance; such, for instance, as water, so that the vibrations of the plunger or rod A′, which does not quite touch the conductor *b*, will cause variations in resistance, and, consequently, in the potential of the current passing through the rod A′.

Owing to this construction, the resistance varies constantly, in response to the vibrations of the diaphragm, which although irregular, not only in their amplitude, but in rapidity, are nevertheless transmitted, and can, consequently, be transmitted through a single rod, which could not be done with a positive make and break of the circuit employed, or where contact points are used.

I contemplate, however, the use of a series of diaphragms in a common vocalizing chamber, each diaphragm carrying an independent rod, and responding to a vibration of different rapidity and intensity, in which case contact points mounted on other diaphragms may be employed.

The vibrations thus imparted are transmitted through an electric circuit to the receiving station, in which circuit is included an electro-magnet of ordinary construction, acting upon a diaphragm to which is attached a piece of soft iron, and which diaphragm is stretched across a receiving vocalizing chamber *c*, somewhat similar to the corresponding vocalizing chamber A.

The diaphragm at the receiving end of the line is thus thrown into vibration corresponding with those at the transmitting end, and audible sounds or words are produced.

The obvious practical application of my improvement will be to enable persons at a distance to converse with each other through a telegraphic circuit, just as they now do in each other's presence, or through a speaking tube.

I claim as my invention the art of transmitting vocal sounds or conversations telegraphically, through an electric circuit.

ELISHA GRAY.

Witnesses:

WILLIAM J. PEYTON,

WM. D. BALDWIN.

3803

STATE OF
COUNTY OF *District of Columbia.* } ss.

Elisha Gray, the within named petitioner, being duly sworn, doth depose and say, that he verily believes himself to be the original and first inventor of the Art of Transmitting Vocal Sounds, described in the foregoing specification; that he does not know or believe that the same was ever before known or used; and that he is a citizen of the United States.

ELISHA GRAY.

[SEAL] Subscribed and sworn to before me this 14th day of February, A. D. 1876. } JOHN T. ARMS, *Notary Public.*

To the Commissioner of Patents:

The petition of Elisha Gray, of Chicago, in the County of Cook, in the State of Illinois, respectfully represents, that he has made certain improvements in the Art of Transmitting Vocal Sounds Telegraphically, and that he is now engaged in making experiments for the purpose of perfecting the same, preparatory to applying for Letters Patent therefor.

He therefore prays that the subjoined description of his invention may be filed as a Caveat in the confidential archives of the Patent Office.

ELISHA GRAY.

PATENT OFFICE,
FEB. 14, 1876,
U. S. A.

[Official Stamp.]

Copy sent Feb. 19, S. R. A.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb'y. 19, 1876.

SIR:

You are hereby notified that application has been made to this Office for Letters Patent for Telephonic Telegraph, &c., with which the invention described in your caveat, filed on the fourteenth day of February, 1876, apparently interferes, and that said application has been deposited in the confidential archives of the Office under

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provision of section 4902 of the Revised Statutes of the United States, which section reads as follows: —

Section 4902. Any citizen of the United States who makes any new invention or discovery, and desires further time to mature the same, may, on payment of the fees required by law, file in the Patent Office a caveat, setting forth the design thereof, and of its distinguishing characteristics, and praying protection of his right until he shall have matured his invention. Such caveat shall be filed in the confidential archives of the Office and preserved in secrecy, and shall be operative for the term of one year from the filing thereof, and if application is made within the year by any other person for a patent with which such caveat would in any manner interfere, the Commissioner shall deposit the description, specification, drawings, and model of such application in like manner in the confidential archives of the Office, and give notice thereof, by mail, to the person by whom the caveat was filed. If such person desires to avail himself of his caveat, he shall file his description, specification, drawings, and model within three months from the time of placing the notice in the post-office in Washington, with the usual time required for transmitting it to the caveator added thereto; which time shall be indorsed on the notice. An alien shall have the privilege herein granted, if he has resided in the United States one year next preceding the filing of his caveat, and has made oath of his intention to become a citizen.

If you would avail yourself of your caveat, it will be necessary for you to file a complete application within three months from date, three days additional, however, being allowed for the transmission of this notice to your place of residence.

Very respectfully,

R. H. DUELL,
Commissioner.

ELISHA GRAY,
Care W. D. Baldwin,
Present.

EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb. 19, 1876.

E. GRAY,
Care W. D. Baldwin.

In relation to the foregoing notice in relation to your Caveat, it may be well to add that the matters in the app'n referred to seem to conflict with your Caveat in these particulars, viz: —

1st, The receiver set into vibration by undulatory currents.

2d, The method of producing the undulations by varying the resistance of the circuit.

3d, The method of transmitting vocal sounds telegraphically by causing these undulatory currents, etc.

Z. F. WILBER,
Examiner.

Copy sent
Feb. 25,
S. R. A.

EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb. 25, 1876.

E. GRAY,
Care W. D. Baldwin, *Present.*

Caveat for Art of Transmitting Vocal Sounds Telegraphically.

Feb. 14, 1876.

The notice to complete having been given under a misapprehension of the rights of the parties, is hereby withdrawn.

Z. F. WILBER,
Examiner.

$10 Mail.

MEMORANDUM OF FEE PAID AT
U. S. PATENT OFFICE.

Paper will be filed to-day.

INVENTOR,
E. Gray.

3806

CAVEAT.

INVENTION,
Transmitting Vocal
Sounds Telegraphically.

DATE OF PAYMENT,
Feb'y 14, 1876.

FEE,
$10.

SOLICITOR,
Wm. D. Baldwin.

PATENT OFFICE,
FEB. 14, 1876.
U. S. A.

[Official Stamp.]

1876.

No. CAVEAT. *Wilber* 48.

ELISHA GRAY.

Of . . . . . Chicago . . . . . .
County of . . . . Cook . . . . . .
State of . . . . Illinois . . . . . .

Art of Transmitting Vocal
Sounds Telegraphically.

Rec'd . . . . . Feb. 14, 1876 . . . . .
Petition . . . . " " " . . . . .
Affidavit . . . . " " " . . . . .
Specification . . . " " " . . . . .
Drawing Within . . . " " " . . . . .
Model . . . . . .
Cert. dep. . . . . .
1 Cash, $10 . . . . Feb. 14, 1876 . . . . .
Circular . . . . . .
2. . . . . .
3. . . . . .

W. D. BALDWIN,
Present.

3807

1. Letter to Caveator, Feb'y 19, 1876. [Notice to Complete.]
2. Letter, Feb'y 25, 1876.

Simmons
vs.

158	S X
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Copy sent
Sept. 20, 1877.
M. E. S.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Sept. 20th, 1877.

ELISHA GRAY,
Care Baldwin, Hopkins & Peyton, *Present.*

SIR:

You are hereby notified, that application has been made to this office for Letters Patent for Speaking Telegraph, involving the use of a series of diaphragms in a common vocalizing chamber, with which the invention described in your caveat, filed on the fourteenth day of February, 1876, renewed Feb. 14, 1877, apparently interferes, and that said application has been deposited in the confidential archives of the office, under provisions of Section 4,902 of the Revised Statutes of the United States, which section reads as follows:—

SECT. 4,902. — Any citizen of the United States who makes any new invention or discovery, and desires further time to mature the same, may, on payment of the fees required by law, file in the Patent Office a caveat, setting forth the design thereof, and of its distinguishing characteristics, and praying protection of his right until he shall have matured his invention. Such caveat shall be filed in the confidential archives of the office, and preserved in secrecy, and shall be operative for the term of one year from the filing thereof; and if application is made within the year by any other person for a patent with which such caveat would in any manner interfere, the Commissioner shall deposit the description, specification, drawings and model of such application in like manner in the confidential archives of the office, and give notice thereof by mail,

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to the person by whom the caveat was filed. If such person desires to avail himself of his caveat, he shall file his description, specification, drawings and model within three months from the time of placing the notice in the post office in Washington, with the usual time required for transmitting it to the caveator added thereto, which time shall be indorsed on the notice. An alien shall have the privilege herein granted, if he has resided in the United States one year next preceeding the filing of his caveat, and has made oath of his intention to become a citizen.

If you would avail yourself of your caveat, it will be necessary for you to file a complete application within three months from date, three days additional, however being allowed for the transmission of this notice to your place of residence.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

MEMORANDUM OF FEE PAID AT
U. S. PATENT OFFICE. 108

INVENTOR,
$10 Elisha Gray.

RENEWAL OF CAVEAT,
Filed Feb. 14, 1876.

INVENTION.
Telegraphy.

DATE OF PAYMENT.
Feb. 14, 1877.

FEE,
$10.

3809

WM. D. BALDWIN,
Solicitor.

Present.

PATENT OFFICE,
FEB. 14, 18.7,
U. S. A.
[Official Stamp.]

1877.

48
—
23

Wilber.

No. 1st. Renewal of Caveat of Feb. 14, 1876.

ELISHA GRAY,

Of . . . . . Chicago . . . . . .
County of . . . . Cook . . . . . .
State of . . . . Illinois . . . . . .

ART OF TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY.

Teleloge.

Rec'd . . . . . Feb. 14, 1877 . . . .
Petition . . . . . .
Affidavit . . . . . .
Specification . . . . . .
Drawing . . . . . .
Model . . . . . .
Cert. dept. . . . . .
1. Cash $10 . . . . Feb. 14, 1877 . . . .
2. Circular . . . . . .
3.

WM. D. BALDWIN,
Present.

Notice to Caveator.
Sept. 20, 1877.

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DEFENDANT'S EXHIBIT EXTRACT FROM BELL'S LONDON LECTURE, W. C. W., EXAMINER.

[INTRODUCED RECORD, PAGE 183.]

Extract from paper read by PROFESSOR ALEXANDER GRAHAM BELL, *October* 31, 1877, *before the Society of Telegraph Engineers, entitled "Researches in Electric Telephony."*

It occurred to me that if a membrane as thin as tissue paper could control the vibrations of bones that were, compared to it, of immense size and weight, why should not a larger and thicker membrane be able to vibrate a piece of iron in front of an electro-magnet, in which case the complication of steel rods shown in my first form of telephone, Figure 19, could be done away with, and a single piece of iron attached to a membrane be placed at either end of the telegraphic circuit.

Figure 22 shows the form of apparatus that I was then employing for producing undulatory currents of electricity for the purposes of multiple telegraphy. A steel reed A was clamped firmly by one extremity to the uncovered leg *h* of an electro-magnet E, and the free end of the reed projected above the covered leg. When the reed A was vibrated in any mechanical way, the battery current was thrown into waves, and electrical undulations traversed the circuit B E W E′, throwing into vibration the corresponding reed A′ at the other end of the circuit. I immediately proceeded to put my idea to

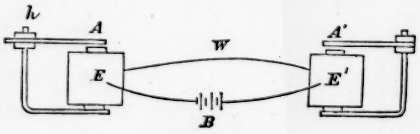


FIG. 22.

the test of practical experiment, and for this purpose I attached the reed A (Figure 23) loosely by one extremity to the uncovered pole *h* of the magnet, and fastened the other extremity to the centre of a

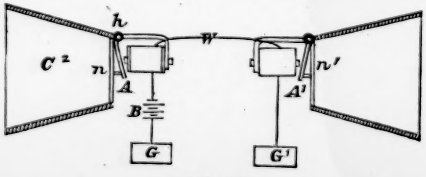


FIG. 23.

stretched membrane of goldbeater's skin *n*. I presumed that upon speaking in the neighborhood of the membrane *n* it would be thrown into vibration, and cause the steel reed A to move in a similar manner, occasioning undulations in the electrical current that would correspond to the changes in the density of the air during the production of the sound; and I further thought that the change of the intensity of the current at the receiving end would cause the magnet there to attract the reed A′ in such a manner that it should copy the motion of the reed A, in which case its movements would occasion a sound from the membrane *n*′ similar in *timbre* to that which had occasioned the original vibration.

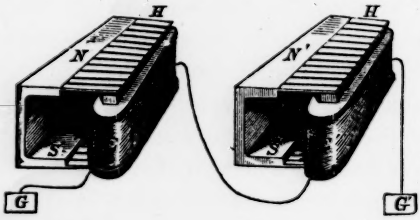
The results, however, were unsatisfactory and discouraging. My friend, Mr. Thomas A. Watson, who assisted me, in his first experiment declared that he heard a faint sound proceed from the telephone at his end of the circuit, but I was unable to verify his assertion. After many experiments, attended by the same only partially successful results, I determined to reduce the size and weight of the spring as much as possible. For this purpose I glued a piece of clock spring, about the size and shape of my thumb nail, firmly to the centre of the diaphragm and had a similar instrument at the other end; we were then enabled to obtain distinctly audible effects.

DEFENDANT'S EXHIBIT SECOND EXTRACT FROM BELL'S LONDON LECTURE, W. C. W., EXAMINER.

[INTRODUCED RECORD, PAGE 220.]

I therefore devised the apparatus shown in Figure 19, which was my first form of articulating telephone. In this figure a harp of steel rods is employed, attached to the poles of a permanent magnet, N, S. When any one of the rods is thrown into vibration, an undulatory current is produced in the coils of the electro-magnet E, and the electro-magnet E′ attracts the rods of the harp H′ with a varying force, throwing into vibration that rod which is in unison with that vibrated at the other end of the circuit. Not only so, but the amplitude of vibration in the one will determine the amplitude of

vibration in the other, for the intensity of the induced current is determined by the amplitude of the inducing vibration, and the am-



plitude of the vibration at the receiving end depends upon the intensity of the attractive impulses. When we sing into a piano, certain of the strings of the instrument are set in vibration sympathetically by the action of the voice with different degrees of amplitude, and a sound, which is an approximation to the vowel uttered, is produced from the piano. Theory shows that, had the piano a very much larger number of strings to the octave, the vowel sounds would be perfectly reproduced. My idea of the action of the apparatus, shown in Figure 19, was this: Utter a sound in the neighborhood of the harp H, and certain of the rods would be thrown into vibration with different amplitudes. At the other end of the circuit the corresponding rods of the harp H′ would vibrate with their proper relations of force, and the *timbre* of the sound would be reproduced. The expense of constructing such an apparatus as that shown in Figure 19 deterred me from making the attempt, and I sought to simplify the apparatus before venturing to have it made.

DEFENDANT'S EXHIBIT SCHELLEN TRANSLATION, W. C. W., EXAMINER.

[INTRODUCED RECORD, PAGE 337.]

TRANSLATION FROM WORK ENTITLED "DER ELEKTROMAGNETISCHE TELEGRAPH," BY DR. H. SCHELLEN, 1867 PAGES 539–542.

"Figure 375 represents the action of the electro-magnet E upon the printing mechanism of the apparatus, and also the device for coupling together the two parts b_1 and b' of the printing axis.

"The cores of the electro-magnet are not connected together at the back by a yoke, as in the case of an ordinary electro-magnet,

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but as shown in Fig. 376, they are attached to the N and S poles of a powerful steel magnet. The action of this magnet upon the cores is regulated by means of an armature of soft iron placed on the legs N and S, which can be moved up or down. The nearer it is placed to the end of the poles the less will be the magnetic effect upon the cores of the electro-magnet.

"By this arrangement the cores are constantly magnetic, and attract the armature *n* (Fig. 375) as long as no current passes through the coils. A strong steel spring *r* operating on the arm F serves, by its attractive power, to withdraw the armature, when by the passage of a current through the coils, the magnetic power derived from the steel magnet is neutralized. In order to avoid too strong an attraction, the armature does not touch the surface of the poles, but is separated by a space equal to about the thickness of an ordinary sheet of paper.

"When a current whose polarity is opposite to the polarity of the steel magnet is passed through the coils E E the magnetism is weakened or neutralized, and it no longer holds the armature against the retractile force of the spring *r*, which immediately draws the armature upward with considerable power. This movement is com-

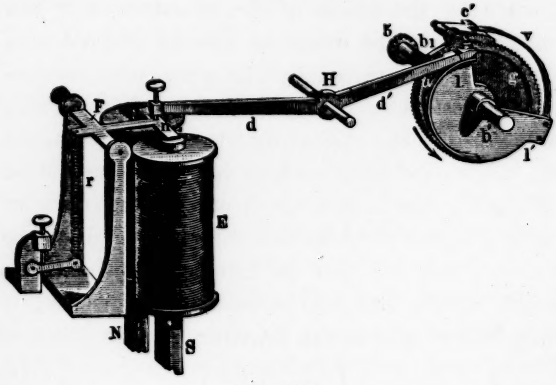

FIG. 375.

FIG. 376.

municated to the lever *d d'*, which has its centre of motion at the axis H. One end of the lever rests, with an adjusting screw, on the top of the armature; therefore, when under the action of the current, the armature is released and flies upward, one extremity *d* is raised with it, while the other goes downward, and it is by this

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movement that the coupling of the two portions of the printing axis $b_1 b'$ (Figs. 369 and 370) is effected, and the motion of the wheel work transmitted from the pinion 5 to the front part of the printing axis b' and its four cams.

"The transmission of this motion is effected in the following manner. On the back part of the printing axis b_1, a wheel g (Fig. 375), with very fine and strong teeth, is fixed. On the front part of the axis b' is a circular sector $l\,l'$, on one side of which is a flyer c', to which is attached a detent c''. This detent has three teeth which gear into the teeth of wheel g. On the other side of the sector is a spring v which presses down the toothed detent, which, with its flyer c', is allowed to rise and fall a little. When it is free, as represented in Fig. 375, the spring v presses the detent c'', into the teeth of wheel g, and it revolves with the wheel in the direction indicated by the arrow, and thus the rotation of printing axis b_1 at once effects the revolution of the sector $l\,l'$ and the axis b'. When, however, $c'\,c''$ is raised, its teeth leave the wheel g; the latter continues to turn while the motion of the sector and the axis b' is arrested.

"The sector $l\,l'$ also carries an eccentric cam u, which raises the end d' of the lever, when by the action of the armature n it has fallen. This movement presses the armature against the poles of the magnet, where it remains attracted by the permanent magnetism of the cores so long as no current passes through the coils. When in the position shown in the engraving, the sector $l\,l'$ turns in the direction of the arrow, and after making half of a revolution the front part (in Fig. 375 the lowest part) of the cam u slides under the extreme end of lever d'. As the following end of the cam is more distant from the axis b' than the front end, the extreme end of lever d' is raised by the cam, the other end d consequently falls, and the adjusting screw returns the armature to the poles of the electro-magnet.

"In the figure the front end of the cam u has not reached the end of the lever d', therefore this end is depressed, and the toothed detent is still engaged with the teeth of wheel g. When the axis b' is turned a little farther d' will have reached its highest position, and d will be resting against the armature of the magnet. The axis

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b', sector $l\ l'$ and flyer c' continue to revolve; but when the revolution of the axis b' is nearly completed the flyer c', to which c'' is attached, reaches the inclined end of the arm d', which is now firmly held, and moves upward, lifting c'' out of the teeth of wheel g. By this the printing axis b' is disconnected from b_1 and the revolving wheel work and its motion arrested, in which position of rest it remains until the arm d' again falls, owing to the release of the armature by a current passing through the coils, when the flyer c' is set free; c'' again catches into the wheel g, and thus both b' and b_1 are again coupled together. It will be seen that the printing axis b' makes a complete revolution at each action of the electro-magnet, and that the movement of armature n and the release and action of the printing mechanism is effected exclusively by mechanical power, and not by the power of an electric current. The current, during its very short duration, merely weakens or destroys the permanent magnetism of the cores of the magnet, at which the spring r raises the armature n and through the lever $d\ d'$ regulates the motion of the printing mechanism."

EXTRACT FROM PUBLICATION ENTITLED "THE ELECTRIC TELEGRAPH," BY ROBERT SABINE, LONDON, 1867, PAGES 136-138.

[INTRODUCED RECORD, PAGE 68.]

"84. *The Magneto-Induction Key.* — Instead of the Morse key, induction coil, and local battery, Siemens and Halske use also an instrument arranged in the form of a key, by which a coil of wire, wound on a soft iron armature, is oscillated between the poles of a permanent magnet, and develops alternate currents for working the polarized relay.

"The magneto-induction key is shown in Fig. 75 in perspective. S and N are two rows of permanent bar-magnets; the upper ones with their north ends, and the lower ones with their south ends in contact with a stout plate, P, of soft iron in the same way as in the transmitter of the magneto-electric pointer telegraph of the same inventors. Between the poles of this system, and oscillated in an angle of a few degrees by means of a handle, H, in the frame between two screw points, is the soft iron armature, as long as the magnet system is wide, cut in deep longitudinal grooves, on opposite sides,

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as is shown by the sectional sketch Fig. 76. In these grooves the coil C of fine insulated wire is wound. The play of the handle is

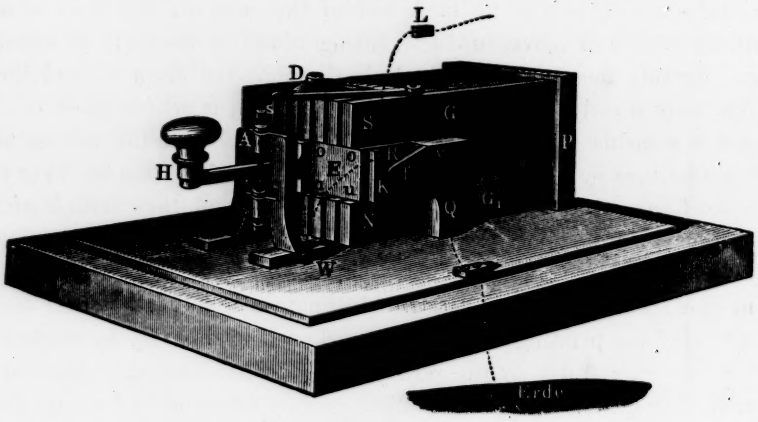

FIG. 75.

limited by two adjusting screws in the frame A. When at rest, the handle is held against the upper screw by a spiral spring, S, stretched between the handle and front of the triangular piece D on the top.

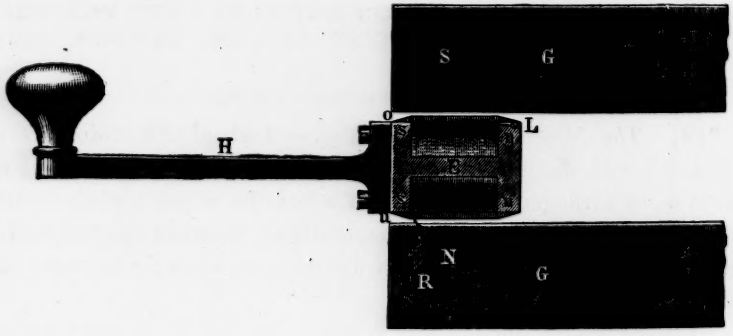

FIG. 76.

"One end of the coil of wire on the armature is attached to the screw *k* on the terminal K, from which one connection goes to line and another to the screw *w*, at the foot of the frame A. The other end of the coil is connected with the metal frame supporting the armature, and through the axis *f*, to the upright support Q, from which a leading wire goes to terminal *t* and earth.

"When a current arrives while the instrument is in circuit with

the line, it goes from L over R, W, upper adjusting screw in A, through handle H, axis *f*, Q, *t*, earth, without traversing the coil. This is the purpose of the connection between R and W.

"When the handle is pressed down, the polarity of the armature is reversed, and a positive magneto-electric current induced in the coil, which circulates also in the line wire, and deflects the tongue of the polarized relay at the receiving station, from the insulated point, and closes the local circuit so long as the key is held down, and no negative current induced by letting the key go back to its position of rest."

EXTRACT FROM PUBLICATION ENTITLED "ELECTRIC TELEGRAPH," BY DR. LARDNER, PAGES 164-167.

[INTRODUCED RECORD, PAGE 68.]

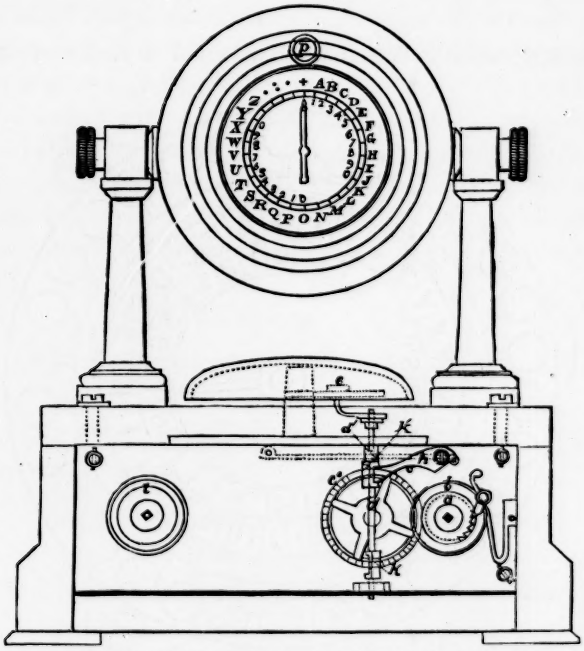

Fig. 109.—Professor Wheatstone's Alphabetical Instrument. (Receiving Apparatus and Alarum.)

"WHEATSTONE'S ALPHABETICAL INSTRUMENT.

"152. The various step-by-step, or letter-indicating, telegraphs may be said mainly to owe their origin to Professor Wheatstone,

whose early labours were mostly in this direction, and who has gradually perfected his apparatus until it has assumed the form now so extensively used for domestic purposes, and especially for communicating between offices, warehouses, etc. The advantage of this class of telegraph is, that those unaccustomed to its use can read the letters as they are successively indicated by the revolving pointer of the receiving apparatus; and, after a very short experience, can in like manner signal the letters with the sending keys.

"From the nature of this form of instrument, and from the large number of currents required for each letter on an average, it is slower in operation than the needle, acoustic, or recording telegraphs. For the reason, combined with the difficulty of working it on any circuit of considerable length, the step-by-step indicating telegraphs have been pretty much restricted to the applications already mentioned.

"In 1858, Professor Wheatstone patented a series of improve-

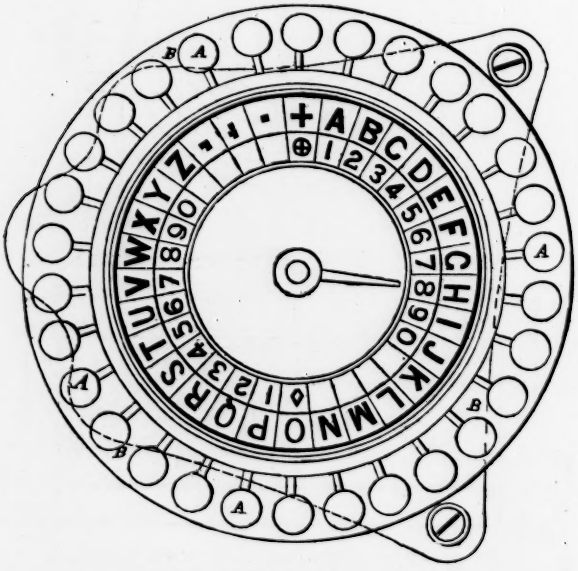

Fig. 110. — Professor Wheatstone's Alphabetical Telegraph. Sending Apparatus.

ments upon the alphabetical instrument introduced by himself and Mr. Cooke in 1840. The object of the new apparatus was to attain

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greater steadiness, certainty, and rapidity than had been previously obtained where an index hand was moved rapidly, step by step, round an alphabetical dial. He embodied his ideas in a simple and yet portable form of instrument, which, from many advantages it possesses, has been very generally adopted for short lines where it is desirable to dispense with skilled telegraph clerks.

"The currents used to work this apparatus are magneto-electric, evolved from permanent magnets; and thus the expense and trouble connected with the use of voltaic batteries in such an arrangement are avoided.

"The arrangement of this apparatus is shown in Figs. 109, 110, 111, and 112.

"Fig. 110 is a vertical view of the outside of the sending apparatus, showing the small finger-studs A A (thirty in number) which, when pressed down, allow such a succession of currents to pass to the distant station, as will move round the indicator on the receiving dial to the corresponding letter.

"Fig. 111 is a section (side view) of the sending apparatus. The handle x is used to turn a pair of electro-magnetic coils (b b) by an endless band, rapidly above the poles of a permanent steel magnet a. A succession of magnetic currents are thus sent, and as long as the handle is turned, and the small finger-studs unmoved, the indicators

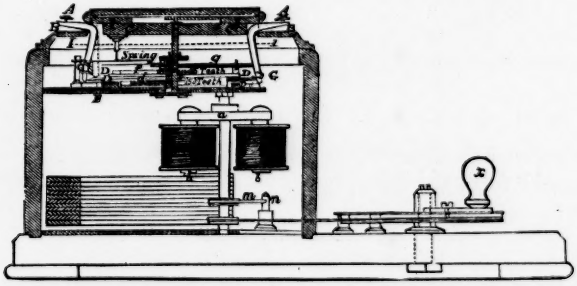

Fig. 111. — Professor Wheatstone's Alphabetical Telegraph — Sending Apparatus (Section).

of the receiving dials move on step by step. On one of the studs A being depressed to the stop B, the movement of the arm g is arrested as soon as it comes round to the lower end G of the finger-key, and the circuit is broken; no further effect being then produced on the

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indicating instrument, its pointer indicates the letter upon the dial to which attention is directed by the pause. An arrangement is made by which when a stud is depressed, it remains down until another is pressed, upon which the first is mechanically returned to its former position.

"Figs. 109 and 112 show the indicating apparatus and alarum. The index or pointer is moved round by a pallet wheel acted upon by the alternate attraction and repulsion of two magnetic needles *h*

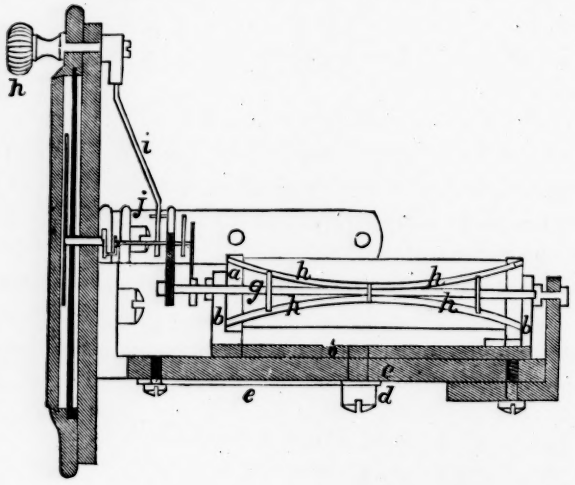

Fig. 112.— Professor Wheatstone's Alphabetical Instrument — Indicating Apparatus (Section).

h fixed upon an axis *g*, by the currents passed from the sending apparatus through the electro-magnets in the receiving instrument.

"*b*, *c*, *d*, *e* form the bearings, and *h*, *i*, *j* is an external regulator."

EXTRACT FROM PUBLICATION ENTITLED "ELECTRICITY," BY ROBERT W. FERGUSON, ETC.

[INTRODUCED RECORD, PAGE 68.]

ELECTRICITY. — R. W. FERGUSON, LONDON, 1867. PAGE 257. THE TELEPHONE. — "This is an instrument for telegraphing notes of the same pitch. Any noise producing a single vibration of the

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air, when repeated regularly a certain number of times in the second (not less than thirty-two), produces, as is well known, a musical sound. In Art. 115, we found that when a rod of iron was placed in a coil of insulated wire, and magnetized by a current being sent through the coil, it gave out a distinct tick when it was demagnetized by the stoppage of the current. A person when singing any note causes the air to vibrate so many times per second, the number varying with the pitch of the note he sings, the higher the note the greater being the number of vibrations. If we then, by any means, can get these vibrations to break a closed circuit in which the coil just mentioned is included, the note sung at one station can be reproduced, at least so far as pitch is concerned, at another. Reiss' Telephone (invented 1861) accomplishes this in the following way: A A (fig. 141) is a hollow wooden box with two round holes in it, one on the top, the other in front. The hole at the top is closed by a piece of bladder S, tightly stretched on a circular frame; a mouth-piece M is attached to the front opening.

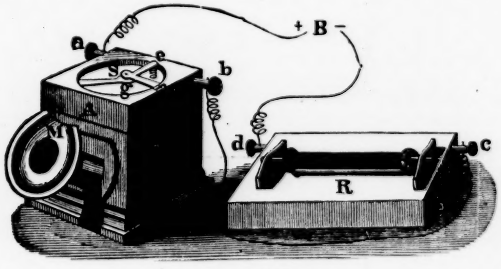

FIG. 141.

"When a person sings in at the mouth-piece, the whole force of his voice is concentrated on the tight membrane, which in consequence vibrates with the voice. A thin strip of platinum is glued to the membrane, and connected with the binding screw *a*, in which a wire from the battery B is fixed. A tripod, *e f g*, rests on the skin. The feet *e* and *f*, lie in metal cups, on the circular frame over which the skin is stretched. One of these *f* rests in a cup containing mercury, and is conneted with the binding screw *b*. The third foot *g*, consisting of a platinum point, lies on the circular end of the strip of platinum just mentioned. This point being placed on the centre of

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the oscillating membrane, acts like a hopper and hops up and down with it. It is easy to understand how, for every vibration of the membrane, the hopper will be thrown up for the instant from connection with its support, and how the close circuit is thus broken at every vibration. The receiving apparatus R consists of a coil of wire placed in circuit, enclosing an iron wire, both being fixed on a sounding box. The connections of the various parts of the circuit are easily learned from the figure. Suppose a person to sing a note at the mouth-piece which produces three hundred vibrations a second, the circuit is broken by the bladder three hundred times, and the iron wire ticking at this rate gives out a note of the same pitch. The note is weak, and in quality resembles the sound of a toy trumpet. Dr. Wright uses a receiving apparatus of the following kind: The line current is made to pass through the primary coil of a small induction coil. In the secondary circuit he places two sheets of paper, silvered on one side, back to back, so as to act as a condenser. Each current that comes from the sounding apparatus produces a current in the secondary circuit which charges and discharges the condenser, each discharge being accompanied by a sound like the sharp tap of a small hammer. The musical notes are rendered by these electric discharges and are loud enough to be heard in a large hall."

DEFENDANT'S EXHIBIT BELL LETTER TO HUBBARD, NOVEMBER 26, 1874, W. P. PREBLE, JR., EXAMINER.

[INTRODUCED RECORD, PAGE 512.]

SALEM, MASS., Nov. 26, 1874.

DEAR MR. HUBBARD:

In your letter of the 14th instant, you allude to the importance of my jotting down whatever facts I can recall concerning the origin of "the multiple telegraph."

It seems to me to be equally important that every *new* step in the development of the idea should be noted.

For this purpose I propose to communicate to you by *letter* the various experiments *as they are made.* This is all the more necessary as I perceive that the important discovery made by me this

afternoon will lead to a total change in the form of apparatus required.

Mr. Blake (father of Dr. Clarence J. Blake) having kindly offered me the use of a room in his building, No. 77 Kilby Street, Boston, I, this morning, proceeded to set up there the apparatus constructed for me by Mr. Hamilton (Mr. Farmer's assistant).

These consisted of two transmitting instruments and two receiving instruments.

The transmitting instrument consisted of an electro magnet E, presenting a single pole to a small cylindrical armature A, which was fastened to an upright strip of brass B. The brass strip in vibrating made and broke contact with the screw S.

The electro-magnet E, the armature A, and the screw S could be lowered or raised as desired, by loosening screws which passed through vertical slots in their supports.

The receiving instruments were like the transmitting apparatus, excepting that the screws S and their supports were omitted.

About noon to-day, the instruments were arranged on circuit as shown in Fig. 2.

On depressing K^1 the armature R^1 vibrated, but no motion was perceptible in that of R^2.

On depressing K^2 the armature of R^2 vibrated, but no motion was perceptible in that of R^1.

On depressing K^1 and K^2 simultaneously, the armatures of R^1 and R^2 were thrown into strong vibration.

One cell of the battery sufficed to produce these results. For the purpose, however, of studying the effects carefully I used three cells.

T^1 and T^2 then vibrated so strongly that I was forced to take R^1 and R^2 into a closet at some distance. Having placed a weight upon K^1 so as to depress it, I repaired to the closet and closed the door so as to shut off the noise of T^1 as much as possible.

I then heard very distinctly the vibrations of R^1. Fastening a piece of elastic cord to the armature R^1 as a damper, I was gratified to find that the cord did not interfere with the noise of the instrument excepting to weaken it.

On examining the armature closely I was surprised at being unable to perceive any motion. Still more was I astonished when I

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found that I could not in any way stop the noise of the instrument even by grasping the armature firmly in my hand.

On removing the armature altogether the instrument continued sounding.

I then discovered that the noise proceeded from the *solid iron core of the electro-magnet.*

On examining R^2 a similar noise was found to be coming from it although its armature did not vibrate sensibly.

On disconnecting the wires the noise stopped. On altering the pitches of T^1 and T^2 the changed pitches were echoed by the electro-magnets of R^1 and R^2.

My first supposition was that the vibrations had been transmitted *mechanically* along the wire.

To settle this point I tried the following experiments: I completed the circuit so as to prevent any current from passing the coils of R^1 and R^2. On pressing the wires firmly against the sounding-boards and other parts of the instrument no sound was emitted, although T^1 was vibrating strongly all the time. To still further lessen the chance of the mechanical transmission of vibrations, I carried the instruments out of the room into a passage beyond. I shut the door and held the instruments in my hands so as to avoid contact with a solid body.

The sound continued to be emitted. Just at this juncture a young man (Mr. Nelson) who is employed about the building happened to come in. I requested him to enter the room and raise and depress K^1 several times. The moment K^1 was depressed the instrument in my hand echoed the pitch of T^1. The instant K^1 was raised the sound stopped. The armature of T^1 vibrated continuously all the time.

It was, therefore, evident that the sound resulted from the passage of the electrical current, and that the vibrations were not transmitted *mechanically* by the wire.

I have been reflecting all the evening upon the *cause* of this strange phenomenon, and I think that I have discovered it. The solution, if correct, points to other still stranger phenomena.

My idea is this: —

When a current of electricity passes through the coils of an electro-

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magnet, the molecules of iron in the core become magnetic and attract each other, approaching nearer together than they were. When the current stops they resume their former places.

This is borne out by the fact (that I have read somewhere) that a soft iron bar becomes *shorter* on being magnetized.

Hence an intermittent current of electricity passed through the coils of an electro-magnet should induce a *molecular vibration* in the core; and perhaps this molecular vibration may have been the cause of the sounds heard by me this evening.

The theory may easily be put to the test in a novel way.

Faraday, in his researches on magnetism and dia-magnetism, discovered that oxygen gas is magnetical like soft iron. Hence it may be possible that a so-called empty coil of wire may induce in the oxygen of its contained air vibrations corresponding to the intermittent current traversing the wire.

Should this prove to be the case, the cavity in the coil could be made of such a size as to re-inforce the sound by *resonance*. Of course this is only *speculating*, but it is easy to put it to the test.

It will be an *experimentum crucis* for the above theory.

Yours very truly,

A. GRAHAM BELL.

GARDINER G. HUBBARD, Esq.,
Brattle Street, Cambridge.

DEFENDANT'S EXHIBIT BELL CAVEAT, W. P. PREBLE, JR., EXAMINER.

[INTRODUCED RECORD, PAGE 512.]

To the Commissioner of Patents:

The petition of Alexander Graham Bell, of Salem, in the county of Essex, and State of Massachusetts, respectfully represents: That he has made certain improvements in the mode of transmitting a number of telegraphic messages simultaneously along a single wire, and that he is now engaged in making experiments for the purpose of perfecting the same preparatory to his applying for Letters Patent therefor. He therefore prays that the subjoined description of his

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invention may be filed as a caveat in the confidential archives of the Patent Office, agreeably to the provisions of the act of Congress, in that case made and provided, he having paid ten dollars into the Treasury of the United States, and complied with the other provisions of the said act.

And he hereby authorizes Joseph H. Adams, of Boston, Massachusetts, to act as his attorney in the matter of the said caveat, and to receive the certificate of deposit for the same.

A. GRAHAM BELL.

THE MULTIPLE TELEGRAPH.

Specification.

The nature of my invention, or discovery, consists in the application of acoustical principles to telegraphy so as to permit of the simultaneous transmission of a large number of messages along a single wire without confusion with one another.

Signals must be made by means of regularly intermittent currents of electricity passed along the line-wire, and must be distinguished from one another by the employment of electro-magnets whose armatures are capable of vibrating at a definite rate of speed.

Several messages may be sent simultaneously along a single wire, if the signals made for any one message have a certain definite pitch different from those employed for the others.

The signals transmitted for each message will affect only that receiving instrument whose armature, in vibrating, yields the pitch employed.

By this means any station upon a telegraphic circuit may communicate with any other, while messages are passing between other places on the same line.

The total number of messages that may be sent simultaneously, upon the acoustical principle, without confusion, depends upon the number of musical notes that can be found which are not harmonies of one another.

In order that a single wire may suffice for communication in *both directions*, an induced current is employed. The duplex principle

may then be used to double the number of messages possible on the acoustical plan.

The system of multiple telegraphy admits of the employment of relays, and of self-recording instruments. The ordinary Morse alphabet may be used.

The instruments I have employed are described in the accompanying drawings, but there are many other devices by which the same results may be accomplished.

The apparatus required consists of three parts, viz., transmitting instruments, transmitting keys,and receiving instruments.

TRANSMITTING INSTRUMENTS.

These consist of devices for opening and closing the electrical circuit a definite number of times per second. This may be accomplished by the employment of *vibrating armatures* (consisting of metallic plates, or rods, wires, stretched membranes, tuning forks, &c.,) *revolving cylinders stringed* or *wind musical instruments*, or by the use of *other contrivances.*

The intermittent current may also be induced upon the line-wire by means of a *permanent magnet* in place of a battery.

TRANSMITTING KEYS.

Any of the keys now in use on telegraphic lines may be employed for the purpose of directing the electrical vibrations caused by the transmitting instrument on to the line wire when signals are to be sent.

RECEIVING INSTRUMENTS.

These consist of electro-magnets with vibrating armatures having definite rates of vibration.

The said armatures may be made of any material or materials whatever, so long as they are capable of being set in vibration by electro-magnets.

They may consist of tuning-forks, rods, plates, strings, or membranes; or may take any form capable of definite vibration.

ARRANGEMENT ON CIRCUIT.

Each station on a telegraphic circuit is to be provided with a number of receiving instruments whose armatures are tuned to *differ-*

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ent pitches; corresponding transmitting instruments and keys are to be added. Should a message be passing along the line-wire, an operator at a station can tell from the receiving instrument affected, what pitch is being employed. He may then send a message on the same line, by using a transmitting key, which throws vibrations of *different pitch* on to the line-wire.

It may be convenient to assign to each station on a line a distinct pitch which shall distinguish its signals from those of other places. In this case a single transmitting instrument and key and a complete set of receiving instruments will suffice for each station.

HISTORY OF THE INVENTION.

The idea of a multiple telegraph suggested itself to me from the consideration of certain acoustical phenomena.

If we press down the pedal of a piano and sing a note, the sound-waves, striking against the strings of the instrument, cause that one to resound which corresponds in pitch to the note sung.

If an electro-magnet is placed over each string, and all the magnets are united in one circuit, — a series of electrical impulses, corresponding in number and regularity to the sounding-waves existing in the air, — passed along the wire, will cause a similarly regular intermittent attraction to appear at the magnets, and *that string whose rate of vibration is the same, will resound.*

In the one instance, all the strings receive a definite number of *pushes* per second from the air; in the other, a definite number of *pulls* per second from the magnets.

As the effect of pulling a string on one side is exactly equivalent to pushing it from the other, it is evident that whatever phenomena result from the action of aerial pulses upon the strings, must also ensue from attractive impulses from the magnets. However many notes are sung simultaneously into the piano, each system of sound-waves affects its corresponding string as readily as if the other systems had no existence. Hence, however many different series of regular intermittent attractions appear simultaneously at the magnets, each one must affect its corresponding string as though it came alone.

It was during the year 1869, or previously, that I first realized

the idea that it was possible, *by the employment of vibrating armatures having definite rates of vibration to distinguish between signals sent simultaneously along the same circuit.*

In the year 1870, the French translation of Helmholtz' work, "*Die Lehre von dem Tonempfindungen*," fell into my hands. The study of the apparatus by means of which he succeeded in imitating vowel sounds, gave me my first ideas of a telegraphic instrument for the transmission of signals possessing the property of pitch. No opportunity, however, offered for experiment until the winter of 1872–3, when I constructed the instruments shown in Fig. 1 on the model of Helmholtz's apparatus. See *Théorie Physiologique de la Musique*, pages 154, 155 and 510.

About May, 1873, an illness forced me to leave Boston, and it was not till October or November of the same year that I was enabled to recommence work upon the multiple telegraph.

An article puplished in The Wonders of Electricity, entitled The Acoustic Telegraph, led me to substitute metallic plates for tuning-forks in my telegraphic experiments.

Accordingly, in the winter of 1873–4, I constructed the instruments shown in Figs. II and III.

By the commencement of the present year (1874), I had proved the practicability of my idea to my own satisfaction, but I felt the need of assistance from practical telegraphers in working out the details of the invention.

Finding that I could not protect my invention in this country without becoming an American citizen, I wrote the following letter to the Hon. Mr. Scudamore, superintendent of telegraphs in England, offering to submit the invention to the proper authorities there:

[Copy.]

"292 Essex Street, Salem, Mass.,
January 10, 1874.

"Sir: I have invented a method by which a large number of telegraphic messages can be sent along the same wire at the same time, without confusing with one another.

A B C D

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"Any station B, may communicate freely with any other station C, while messages are passing from A to D, from D to A, from A to C, etc.

"The possible number of simultaneous messages that can be transmitted on this principle, may be doubled by the use of the duplex system.

"As I am a British subject, I wish to place this idea at the disposal of the British government, and, therefore, before making any efforts to interest American telegraphers in the scheme, I write to request an investigation.

"Yours respectfully,

"A. GRAHAM BELL,
Professor of Vocal Physiology
in the University of Boston, Mass.

"Hon. —— SCUDMORE,
Superintendent of Telegraphs,
London, England."

An answer was received from the Post Office Department in London, which effectually prevented any further correspondence. It was as follows:

"No. 11,566.

"GENERAL POST OFFICE,
22*d January*, 1874.

"SIR: With reference to your letter of the 10th instant, I beg leave to inform you that if you will submit your invention it will be considered, on the understanding however, that the department is not bound to secrecy in the matter, nor to indemnify you for any loss or expense you may incur in the furtherance of your object, and that in the event of your method of telegraphy appearing to be both original and useful, all questions of remuneration shall rest entirely with the Postmaster General.

"I am, sir,

"Your obedient servant,

"JOHN TILLEY.

"No. 164.

"A. GRAHAM BELL, ESQ.,
292 *Essex Street, Salem.*"

I have now taken the necessary steps as required by law to become an American citizen, and I desire to file a caveat in order to protect myself while perfecting my invention.

RECAPITULATION.

What I claim as my invention and desire to secure by Letters Patent is: *The application of acoustical principles to telegraphy, so as to permit of the simultaneous transmission of a large number of messsges along a single wire without confusion with one another.*

The special point in this invention which I desire to protect is: *The employment of armatures having definite rates of vibration as a means of distinguishing between signals sent separately or simultaneously along the same circuit.*

(The said armatures may be made of any material or materials whatsoever, so long as they are capable of being set in vibration by electro-magnets. They may consist of tuning-forks, rods, plates, strings, or membranes, or may take any form capable of definite vibration.)

A. GRAHAM BELL.

DESCRIPTION OF APPARATUS.

Fig. 1. This diagram illustrates the transmitting and receiving instruments constructed by me on the model of Helmholtz's apparatus for the artificial production of vowel sounds. (See "*Theorie Physiologique de la Musique*," pp. 154 and 510.)

A tuning-fork F is placed horizontally between the poles of an electro-magnet E, E^1. A bent platinum wire W, soldered to the upper prong of the fork, dips into the mercury cup M, so as to touch the surface of the mercury. The apparatus is connected with the transmitting key C. The stem of key K rests against a metallic bridge B, which is connected with the Z pole of the battery B.

The receiving instrument D consists of a tuning-fork *f*, placed between the poles of the electro-magnet *e*, e^1.

ACTION OF THE APPARATUS.

When the platinum wire W touches the surface of the mercury in the cup M, a current traverses the circuit c, M, W, F, E, E^1, K, B, Z.

The pole P of the electro-magnet attracts the upper prong of the fork. The platinum wire W is thus lifted out of the mercury, and the circuit is broken.

The prong, no longer attracted, falls back and allows the wire W once more to dip into the mercury.

The fork F is thus caused to vibrate continuously, and in so doing, makes and breaks contact with the mercury in the cup M. The result is, that a regularly intermittent current, corresponding to the vibration of the fork F, traverses the circuit *c*, M, W, F, E, E^1, K, B, Z.

The transmitting instrument A is put into circuit with the line by depressing the key C. The currents of B pass from Z through G to the earth, and from *c* through M, W, F, E, E^1, K, L, to the line wire, and thence through *e*, e^1, to the ground at *g*.

Thus the intermittent current created by the vibrations of the fork F will pass through the coils of the electro-magnet *e*, e^1, of the receiving instrument D, causing a corresponding intermittent attraction at its poles.

If the tuning fork *f* is in unison with the generating fork F, it will resound loudly. If, on the other hand, it is discordant with F, it will be silent. Supposing *f* to be in unison with F, every time the key C is depressed the tuning fork *f* will resound. When the key is raised the vibrations of *f* speedily die away. Thus the signals of the Morse alphabet may be made by the key C, and the tuning fork *f* will reproduce the signals with the pitch due to the vibrations of the fork F. In rapid signaling it will be advisable to apply a damper to the fork *f*, so as to stop its vibrations the moment the magnetical stimulus has ceased.

Fig. II. The arrangement of the apparatus shown in this diagram is identical with that illustrated in Fig. I. Steel plates are, however, substituted for tuning forks.

The electro-magnet E, E^1, attracts the steel plate P, and the platinum wire W is lifted out of the mercury in the cup M. The circuit is broken and the plate falls back to re-establish the current.

The vibrations of the plate cause an intermittent current to traverse the circuit *c*, M, W, P, E, E^1, K, B, Z.

On pressing down the key C, the intermittent current passes on to

the line wire through L, and affects the steel plate p of the receiving instrument D.

A resonator R, is used to reinforce the vibrations of the plate p, and thus strengthen the signals.

Fig. III. The apparatus shown in this diagram is similar to that illustrated by Fig. II, excepting that the steel plate P vibrates against the extremity of a screw S, instead of making and breaking contact with a mercury connection.

Fig. IV shows the arrangement of instruments (similar to those illustrated in Fig. II) on a telegraphic circuit.

A, B, C, &c., N, are stations on the line. Each station is provided with a number of receiving instrumens, R^1, R^2, R^3, R, &c., and corresponding transmitting instruments T^1, T^2, T^3, T, &c.; keys K^1, K^2, K^3, K, &c.; and batteries B^1, B^2, B^3, B, &c.

The armatures of the transmitting and receiving instruments that are *numbered alike* have the same pitch. Thus T^2 of A, corresponds in pitch to R^2, of A, B, C, &c., N, and to T^2 of B, C, &c.

The pitches adopted for T^1, T^2, T^3, T, &c., are such that T^1 will affect no other receiving instruments than R^1, at any station; T^2, no other than R^2, &c.

Examine station A:

The currents of B^1 traverse the circuit c^1, T^1, b^1, g, z^1.

The currents of B^2 traverse the circuit c^2, T^2, b^2, b^1, g, z^2.

The currents of B^3 traverse the circuit c^3, T^3, b^3, b^2, b^1, g, z^3.

&c., &c., &c.

Upon depressing the key K^1, the currents of B^1 will pass from z^1 to the earth; and from c^1 through T^1, L^1, and through all the receiving instruments R^1, R^2, R^3, R, &c, of stations A, B, C, &c., N, to the earth at N.

The receiving instrument R^1 at all the stations will respond; the other instruments, R^2, R^3, R, &c., will remain silent.

Upon depressing K^2 of A, R^2 at all the stations will respond.

Let K^1 and K^2 of A be depressed simultaneously, the two series of intermittent currents must pass along the line wire together to the earth at N, and the receiving instruments R^1 and R^2 at all the stations will be affected. The others, R^3, R, &c., will remain silent. At first glance it would seem as if the electrical impulses thrown on

to the line at L^1 by K^1 (station A) might return by L^2 through K^2, T^2, c^2, z^2, to z^1. In order that the currents of B^1 should thus interfere with the currents of B^2, they must reach T^2 at the time when the platinum wire attached to its armature is in contact with the mercury in the connection cup. As, however, the vibrations of T^1 do not accord with those of T^2, such a coincidence will not happen.

For similar reasons the intermittent current thrown on to the line wire at L^2 by K^2 will not return through L^1, K^1, &c.

Let K^1 of B be depressed. An intermittent current will pass from K^1 through L^1, and through all the receiving instruments R^1, R^2, R^3. R, &c., of stations B, C, &c., N, to the earth at N.

The current will not pass to station A, because the line wire is not in connection with the earth at A.

Depress K^1 of A and K^2 of B simultaneously. The intermittent current from K^1 of A will be unable to reach the earth through K^2 of B, because the armature of T^2 (station B) does not accord with that of T^1 (station A.) The signals from A can only reach the earth at N, so that the receiving instrument R^1 of *all* the stations A, B, C, &c., N, will be affected.

The intermittent current from K^2 of B cannot reach the earth at A for the reason just stated. Hence it will not pass to A at all, but will seek that station N, where there is free earth communication.

The receiving instrument R^2 of B, C, &c., N, will be affected.

The signals made by any transmitting key will pass only in the direction of that station N where there is free earth communication.

It is evident that with this plan, two wires are necessary to complete communication in both directions.

The arrangement of instruments on the second line wire is similar to that shown in the diagram (Fig. IV), excepting that station A is arranged as N, and N as A.

Fig. V. This diagram is similar to the last, excepting in the arrangement of the batteries.

As the armatures of T^1, T^2, T^3, T, &c., of any station A, do not close the circuit at the same time, one battery will suffice for each station.

For the same reason, each transmitting instrument will act with the full power of the battery.

Fig. VI illustrates the application of the relay to the multiple telegraph.

The action of the transmitting apparatus has been explained in describing Fig. II.

A platinum wire is attached to the plate P of the relay, and dips into a mercury cup M, so as almost to touch the surface of the mercury.

On depressing the transmitting key an intermittent current passes along the line wire through E of the relay, to the earth by the wire *g*.

If the plate P corresponds in pitch to the armature A of the transmitting instrument, it will be thrown into regular vibration.

In vibrating it will make and break contact with the mercury in the cup M.

A fresh intermittent current, similar to that created by the vibration of A, will pass from *c* of the battery B, through M, P, L, to the line wire; thence through *e*, *g*, to the ground. The plate *p* of the receiving instrument will resound if it is in unison with P and A.

Fig. VII illustrates the arrangement of instruments when an intermittent current is to be *induced* upon the line wire.

A, B, C, D, &c., are stations on the line; R^1, R^2, R, &c., are receiving instruments; K^1, K^2, K, &c., keys; b^1, b^2, b^3, the bridges over the keys; I^1, I^2, I, &c., induction coils; A^1, A^2, A, &c., vibrating armatures; M^1, M^2, M, &c., mercury cups, B^1, B^2, B, &c., batteries.

Examine station C. The currents of B^1 traverse the circuit c^1, M^1, A^1, I^1, Z^1.

The vibrating armature A^1 makes and breaks contact with the mercury in the cup M^1.

An intermittent current is *induced* in the closed circuit I^1, b^1, K^1, I^1. The current passes in one direction when contact is made with the mercury at M^1, and in the opposite direction when the contact is broken. Upon depressing the key, the induced currents of I^1, pass from K^1, through the stations B, A, to the earth at N, and from b^1, through C, D, &c., to the earth at N.

Upon depressing any key, an induced intermittent current will

appear at *all* the stations on the circuit. Hence, the induced current may be employed for the transmission of signals in either directions.

I have given this diagram for the purpose of showing how the idea of using an induced intermittent current originated in my mind; but I am well aware that the apparatus as shown in Fig. VII requires much modification in order to be effective.

Fig. VIII, the apparatus that I propose to construct for causing a regularly intermittent *induced* current on the line wire, is shown in this diagram.

OATH.

COUNTY OF SUFFOLK,
State of Massachusetts.

On this twenty-seventh day of October, A. D. 1874, before me, the subscriber, a justice of the peace, in and for the county aforesaid, personally appeared the within named Alexander Graham Bell, and made solemn oath that he verily believes himself to be the original and first inventor of the within-described mode of transmitting a number of telegraphic messages simultaneously along a single wire, and that he does not know or believe that the same was ever before known or used; and that he has resided for one year last past within the United States, and has made oath of his intention to become a citizen thereof.

Before me,

[L. S.] CHARLES E. POWERS,
Justice of the Peace.

DEFENDANT'S EXHIBIT, GRAY'S SPEAKING TELEPHONE, ART APPLICATION.

(RECORD, PAGE 67.)

3838.

ELISHA GRAY. 3 SHEETS No 1

ART OF TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY

FILED OCTOBER 29TH 1877

Fig 1. Fig 2

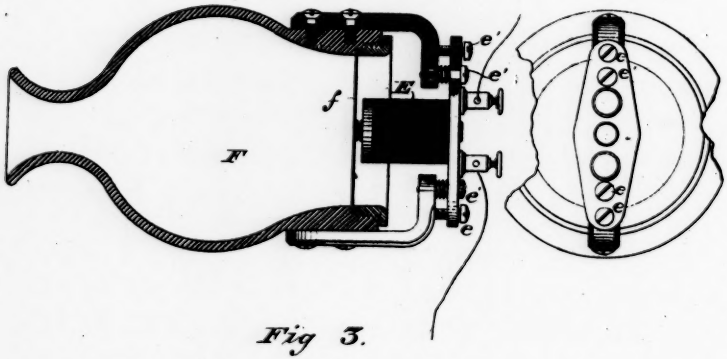
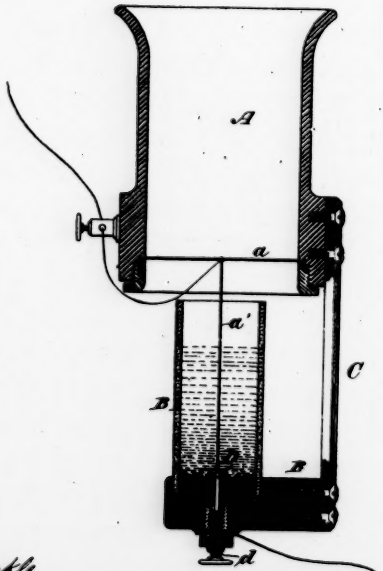


Fig 3.



WITNESSES

Wm A. Stinckle.

Geo W Breck.

INVENTOR

ELISHA GRAY.

By his Attorneys

Baldwin. Hopkins & Peyton

3839

3 Sheets No 2

ELISHA GRAY

ART OF TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY

FILED OCTOBER 29 TH 1877

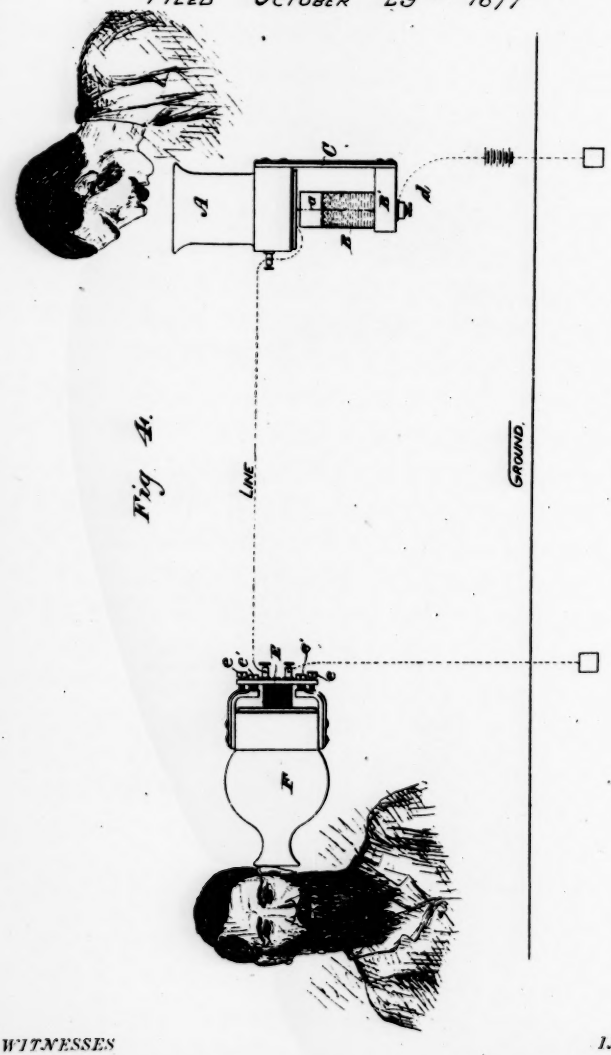


Fig 4.

WITNESSES

Wm A Skinkle

Geo W Breck.

INVENTOR

ELISHA GRAY

By his Attorneys

Baldwin, Hopkins & Peyton

3840

3 Sheets No 3

ELISHA GRAY.

ART OF TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY

FILED OCTOBER 29TH 1877

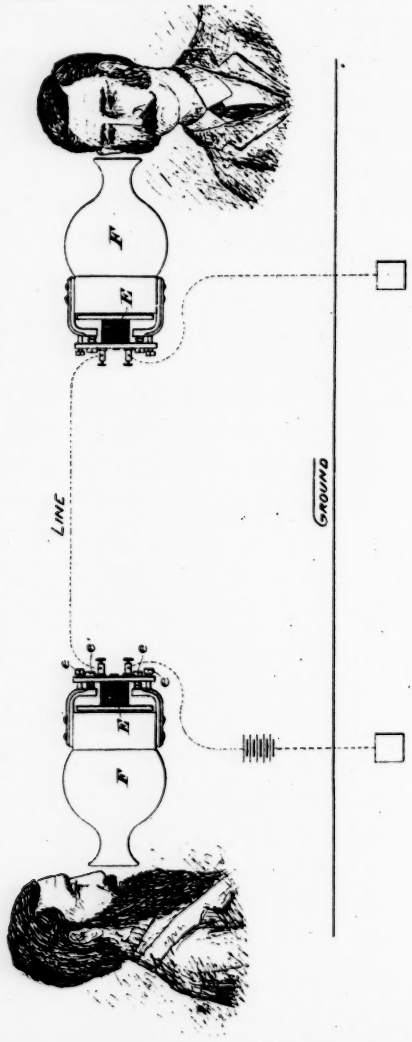


Fig 5.

WITNESSES

Wm A. Skinkle.

Geo W. Buck

INVENTOR

ELISHA GRAY.

By his Attorneys.

Baldwin, Hopkins & Peyton

3841

Defendant's Exhibit.

"GRAY'S SPEAKING TELEPHONE ART APPLICATION."

W. C. W., *Ex'r.*

Department of the Interior,

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the files of this office of the file-wrapper, contents and drawing, in the matter of the application of Elisha Gray, filed October 29th, 1877, for Art of Transmitting Vocal Sounds Telegraphically, &c.

In testimony whereof, I, ELLIS SPEAR, Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this twenty-first day of August, [L. S.] in the year of our Lord one thousand eight hundred and seventy-eight, and of the Independence of the United States the one hundred and third.

ELLIS SPEAR, *Commissioner.*

Case 1.—Application.

To the Commissioner of Patents:

Your petitioner prays that Letters-Patent may be granted to him for the invention set forth in the annexed specification.

Also, that you will recognize Baldwin, Hopkins & Peyton, of Washington City, D. C., as his duly authorized attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and transact all business in the Patent Office connected therewith.

ELISHA GRAY.

To all whom it may concern :

Be it known, that I, ELISHA GRAY, of Chicago, in the County of Cook, and State of Illinois, have invented a new and useful Art of Transmitting Vocal Sounds Telegraphically; as well as certain new and useful Improvements on Apparatus for so Transmitting such Sounds; of which art and apparatus the following is a specification :

The object of my invention is to transmit the tones of the human voice through a telegraphic circuit, and reproduce them at the receiving end of the line, so that oral conversations can be carried on by persons at long distances apart.

I have heretofore invented and patented methods of transmitting musical impressions or sounds telegraphically, and my present improvement is based upon a modification of the principle of said invention set forth and described in sundry Letters-Patent, granted to me July 27, 1875, and respectively numbered 166,095 and 166,096; Letters-Patent, No. 173,460, granted to me February 15th, 1876; and also in an application for Letters-Patent of the United States, filed by me February 23d, 1875.

To attain the objects of my invention, I have devised an apparatus capable of vibrating responsively to all the tones of the human voice, and transmitting said vibrations through the electric circuit, and reproducing them on a receiver correspondingly responsive to the tones of the human voice, and by which they are rendered audible.

The subject-matter claimed will hereinafter specifically be designated.

The accompanying drawings represent apparatus embodying my improvements in the best way now known to me; but I contemplate various other applications and also changes in the details of construction of the apparatus; some of which obviously would suggest themselves to a skilled electrician, or to a person versed in the science of acoustics upon being made aware of my invention.

Figure 1, represents a vertical central section through one form of an apparatus embodying my improvements capable of use either as a transmitter or as a receiver.

Figure 2, is an end view of a portion of the same.

Figure 3, represents a vertical transverse section through another form of transmitting apparatus, which forms the subject-

384'3

matter of another application for Letters-Patent of the United States, filed by me simultaneously herewith.

Figure 4, represents a view of the apparatus arranged upon circuit to illustrate its operation more fully, showing a transmitter similar to that shown in Figure 3, and a receiver similar to that shown in Figure 1, and

Figure 5, shows an arrangement upon circuit similar to Figure 4, with the exception that the transmitter and receiver are both like that shown in Figure 1.

My present belief is that the most effective apparatus capable of responding to the various tones of the human voice, consists of a tympanum or diaphragm combined with a frame or a chamber carrying apparatus for producing changes in the strength of an electric current.

The fundamental distinction between a diaphragm of the character contemplated by me and the one shown in the well-known Reiss Telephone is the absence of the contact-point. Where such contact-point is employed, the apparatus, while capable of transmitting musical tones, is incapable of transmitting articulate sounds or all the tones of the human voice; but when used as contemplated in the present case, not only musical tones as before described may be transmitted, but spoken words or other sounds of whatever character may be transmitted and reproduced at the receiving end of the line so that ordinary conversations may be carried on over the circuit.

The transmitter shown in Figure 3, consists of a box, chamber, or tube A, by preference made with a flaring mouth. Across this chamber is arranged a diaphragm *a*, of some thin substance, such as parchment or goldbeater-skin, capable of responding to all the vibrations of the human voice, whether simple or complex. Attached to this diaphragm is a light metal rod a^1, or other suitable conductor of electricity, which rod extends into the vessel B, of glass or other suitable insulating material, having its bottom closed by a plug, which may be of metal, or through which passes a conductor D, forming part of the circuit. The speaking tube A, and base or stand B^1, which supports the vessel B, are held in a fixed relation to each other by a suitable connecting frame C, or other well known means; and the conductor D, above-mentioned, is mounted upon an adjusting screw *d*, by which means it may be adjusted very close to the rod a^1, without actual contact. The

vibrations of the diaphragm *a*, will thus cause the rod a^1, to vary its relation to the conductor *d*, thus varying the resistance, and consequently the strength of the current passing through the circuit. It will be observed that the degree of variation in the strength of the electric current will correspond accurately with the amplitude and rapidity of the vibrations of the diaphragm, which vibrations, in the enunciation of any given word, are variable, both as to amplitude, rate and complexity.

The vessel B, is filled with some liquid possessing high resistance to the electric current, such for instance, as distilled water or other yielding substance possessing high resistance.

The transmitter must, of course, be mounted in a suitable frame to hold it securely and prevent the waste of the resisting medium where liquid is employed as such medium.

The variations in the strength of the electric circuit, thus produced, are transmitted to the receiving station or instrument, in which circuit is included an electro-magnet of ordinary construction acting upon a diaphragm preferably connected with a vocalizing chamber.

In Figure 1, of the accompanying drawings a vocalizing chamber F, is shown as provided with a diaphragm *f*, to which is attached a piece of soft iron f^1, constituting an armature in close proximity to the core of a magnet E, held in a fixed relation in regard to the vocalizing chamber by a suitable frame and provided with suitable adjusting screws *e*, e^1, to adjust the magnet and diaphragm in proper relation to each other.

A sheet-metal diaphragm might obviously be substituted for the one just described. When a diaphragm of sheet-iron or steel is used, the diaphragm itself constitutes an armature, and the piece of soft iron f^1, Figure 1, may be dispensed with.

The proper proportion, form and mounting of this plate, disk or diaphragm, are important conditions which must be taken into consideration in order to obtain the best results.

The plate or membrane should be thin, preferably circular, equal in length and breadth, and should be rigidly supported at its edges in a proper frame, while the central portion being elastic, is left free to take up and respond to sonorous vibrations of every character.

All solid bodies tend to vibrate at a certain definite rate called the fundamental, and when shaped with reference to the develop-

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ment of this characteristic to the greatest extent, it is difficult to excite vibrations having any degree of amplitude, other than the fundamental rate belonging to them respectively. A tuning fork is an example of a body whose form is calculated to develop this quality in a high degree. On the other hand, the more nearly a body assumes the form of a plate—preferably circular—made thin and supported not at one side alone, but all around its edges, the more it loses its special fundamental character and becomes capable of vibrating at one rate as readily as another. A plate or membra e in which this characteristic is developed in the greatest degree, is best adapted to the transmission and reception of oral conversations.

Figure 4, shows the apparatus above described, arranged upon circuit, the operation of which will readily be understood from the foregoing description. The diaphragm of the transmitter A, is thrown into vibrations by the voice of the operator, and the corresponding diaphragm at the receiving end of the line is thrown into corresponding vibrations with those of the transmitter, and audible sounds or words are produced.

Figure 5, shows two instruments similar to that shown in Figure 1, arranged upon circuit to act both as receivers and transmitters, the operation being the same, although the variations of the current strength are produced in the case of the transmitter first described by variation of resistance, while in the other case they are produced by the *inductive* action of the armature upon the fixed magnet.

By means of the apparatus thus described, persons at a distance can converse with each other through an electric circuit as they now do in each others presence.

What I claim as my invention, and desire to secure by Letters-Patent, is :

1. The hereinbefore described Art of transmitting and reproducing at a distance, sonorous waves or vibrations of any description, which consists in increa ing and decreasing the strength of an electric current traversing a circuit, in such a manner as to produce in said circuit a series of electrical waves or vibrations, precisely corresponding in their intervals of succession and relative amplitudes to the sonorous waves which are to be reproduced at the receiving station or s ations, so that oral conversations or

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sounds of any description whatever may be telegraphically transmitted.

2. The hereinbefore described improvement in the art of transmitting vocal sounds or spoken words telegraphically, which consists in throwing upon the line, through the medium of a varying resistance, electrical impulses corresponding to the vibrations of a diaphragm operated by the movements of the air, produced by a spoken word.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:
WM. D. BALDWIN,
WM. J. PEYTON.

CITY OF WASHINGTON,
DIST. OF COLUMBIA, } *ss:*

ELISHA GRAY, the above-named petitioner, being duly sworn, deposes and says, that he verily believes himself to be the original and first inventor of the Art of Transmitting Vocal Sounds Telegraphically, and Apparatus therefor described in the foregoing specification; that he does not know and does not believe that the same were ever before known or used, and that he is a citizen of the United States.

ELISHA GRAY.

Sworn to and subscribed before me, this 20th day of October, 1877.

[L. S.]

WM. J. PEYTON,
Notaay Public.

U. S.
PATENT OFFICE,
Oct. 29, 18 7.

WASHINGTON, D. C., Oct. 29, 1877.
United States Patent Office.

In the matter of the application of ELISHA GRAY, for Letters-Patent for Art of Transmitting Vocal Sounds Telegraphically, and Apparatus therefor, filed Oct. 29, 1877.

We request that a model may temporarily be dispensed with in the application above mentioned, and that the case be forwarded to the Examiner for his action.

The model will be filed in a few days.

Respectfully,
BALDWIN, HOPKINS & PEYTON,
Att'y's for E. Gray.

To the Commissioner of Patents :

Model can be dispensed with for examination.

J. H. MCDONALD,
Ass't in Ch'g.

App'd.
W. H. DOOLITTLE,
A. C.

U. S
PATENT OFFICE.
Oct. 29, 1877,

1. Rejection.
Oct. 31, 1877.

ROOM No. 118.
(Case 1.
116-73.
Copy sent
Oct. 31, 1877.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Oct. 31, 1877.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Art of Transmitting Vocal Sounds Telegraphically.
Filed Oct. 29, 1877.

This application has been examined and found to be fully met by patent of A. G. Bell, Mar. 7, 1876, No. 174,465. (Elec. Telephonic Telh's.) Magnet E, is not described or shown as being in any manner different from the common form of electro-magnet

consisting of a soft iron core, surrounded with coils of wire. Other characteristics are obviously necessary, in order to make the device operative. On page 8, it is stated that the armature acts inductively. As this armature is stated to be of soft iron, this appears to be hardly correct. The application is accordingly refused.

H. C. TOWNSEND, *Ex'r.*

2. Letter to Office.

Dec. 5, 1877.

WASHINGTON, D. C., Dec. 4, 1877.

To the Commissioner of Patents:

SIR:

Herewith we file a model to complete application of Elisha Gray, for Art of Transmitting Vocal Sounds Telegraphically, filed Oct. 29, '77.

Resp'y,
BALDWIN, HOPKINS & PEYTON,
Att'y's for E. Gray.

U. S.
PATENT OFFICE,
Dec. 5, 1877.

3. Letter to Office.

Dec. 8, 1867.

In the U. S. Patent Office.

In the matter of the application of Elisha Gray, for Letters-Patent for Art of Transmitting Vocal Sounds Telephonically, filed Oct. 29, 1877. (Case 1.)

WASHINGTON, D. C. December 8, 1877.

To the Commissioner of Patents:

SIR: We have the Official Letter of October 31, rejecting the above-mentioned application, and request the prompt declaration of an interference with the reference cited; which, it will [be] observed by reference to the official records, was granted in derogation

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of Gray's Caveat of even date, with the application upon which that patent was granted.

The Office is mistaken as to its assumption of the inoperativeness of the "magnet E" described. Its practicability has been demonstrated by actual working. If an issue is made on this point, proof will be furnished. Moreover, we are unable to perceive why a soft iron armature will not act inductively. Our client, who is an electrician of twenty-odd years experience, knows of no such reason, and on the contrary, has worked it as described in the specification. In fact, soft iron is one of the best known substances for inductive action, being superior even to steel for this particular purpose.

Respectfully,
BALDWIN, HOPKINS & PEYTON,
Attorneys for E. Gray.

U. S.
PATENT OFFICE
DEC. 8, 1877.

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4. Interference A.

March 26, 1878.

ROOM NO. 118. (No. 14.) (INTERFERENCE.)

INTERERENCE A.

116–73.
Copied
Mar. 26, '78.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Mar. 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your application for patent for Art of Transmitting Vocal Sounds Telegraphically, filed Oct. 29, 1877. (No. 1.)

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications and patents named below, and the question of priority

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will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, endorsed on the envelope. The subject-matter involved in the interference is, "The hereinbefore described art of transmitting and reproducing at a distance, sonorous waves or vibrations of any description which consists in increasing and decreasing the strength of an electric current, traversing a circuit in such a manner as to produce in said circuit a series of electrical waves or vibrations precisely corresponding in their intervals of succession and relative amplitudes to the sonorous waves, which are to be reproduced at the receiving station or stations, so that oral conversations or sounds of any description whatever may be telegraphically transmitted." (Gray's 1st Claim.)

This is substantially the method specified in Bell's 5th claim, and is described in the applications of Edison, Berliner, Richmond, Dolbear and Holcombe.

Parties to Interference.

Thomas A. Edison. App'n filed Apr. 27, 1877. (Case 130.) Att'y of record, L. W. Serrell, P. O. Box, 4689, N. Y. City.

Emile Berliner. App'n filed June 4th, 1877. Att'y of record, James L. Norris, Washington, D. C.

George B. Richmond. App'n filed Aug. 24, 1877. Att'y of record, George W. Dyer, Washington, D. C.

A. E. Dolbear. App'n filed Oct. 31, 1877. (A.) Atty's of record, Frank L. Pope, Elizabeth, N. J., James L. Norris, Asso. Att'y, Washington, D. C.

A. G. Holcombe. App'n filed Jan. 28, 1878. Att'y of record, Moses G. Farmer, Torpedo Station, Newport, R. I.

A. G. Bell. Patent No. 174,465, dated Mar. 7, 1876. Att'y of record, A. Pollok, Washington, D. C.

H. C. TOWNSEND, *Ex'r.*

 3857

5. Interference B.

Mar. 26, 1878.

ROOM No. 118. (No. 14.) (INTERFERENCE.)

INTERFERENCE B.

116–73.
Copy
Mar. 26, 1878.
P. W. P.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., March 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your application, filed Oct. 21st, 1877, "Art of Transmitting Vocal Sounds Telegraphically."

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, indorsed on the envelope. The subject-matter involved in the interference is the hereinbefore described improvement in the art of transmitting vocal sounds or spoken words telegraphically, which consists in throwing upon the line through the medium of a varying resistance, electric impulses, corresponding to the vibrations of a diaphragm operated by the movements of the air produced by a spoken word. (Gray's 2d claim.)

This is substantially covered in Bell's 4th claim, and is described in applications of Edison, Berliner and Richmond.

The parties to Interference are:

Elisha Gray, $\frac{116}{73}$. Application filed Oct. 21, 1877. Attorneys of record, Baldwin, Hopkins & Peyton, Washington, D. C.

T. A. Edison, $\frac{72}{64}$. App'n filed Ap'l 27, '77. (Case 130.) Attorney, L. W. Serrell, Box 4689, N. Y. City.

Emile Berliner, $\frac{86}{12}$. App'n filed June 4, '77. Attorney, Jas. L. Norris, Washington, D. C.

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George B. Richmond, $\frac{101}{58}$. App'n filed Aug. 24, '77. Attorney, Geo. W. Dyer, Washington, D. C.

A. G. Bell, $\frac{158}{55}$. Patent No. 174,465, dated March 7, '76. Attorney, A. Pollok, Washington, D. C.

H. C. TOWNSEND, *Ex'r.*

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6. Interference F.

Mch. 26, 1878.

ROOM No. 118. (No. 14.) (INTERFERENCE.)

INTERFERENCE F.

116–73.
Copy made
March 26, 1878.
H. C. T.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., March 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your application, filed Oct. 29, '77. "Art of Transmitting Vocal Sounds Telegraphically." (No. 1.)

Very respectfully,
ELLIS SPEAR,
Commissiomer of Patents.

Your case above referred is adjudged to interfere with the applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, indorsed on the envelope. The subject-matter involved in the interference is a telephonic transmitter, consisting of a coil of wire, one or more magnets, and a disc or diaphragm so arranged relative to each other, that a motion of the diaphragm shall induce in the coil of wire an electro-motive force in virtue of the presence of the magnet or magnets.

This is substantially Holcombe's 1st claim, and is described and shown in applications of Dolbear and Gray, and patent of Bell.

The parties to this Interference are:

A. G. Holcombe. App'n filed Jan. 28, '78. M. G. Farmer, Torpedo Station, Newport, R. I., Att'y.

3853

A. E. Dolbear. App'n filed Oct. 31, '77. F. L. Pope, Elizabeth, N. J., and J. L. Norris, Washington, D. C., Associate.

A. G. Bell. Patent No. 174,465, Mar. 7, '76. A. Pollok, Washington, D. C., Att'y.

H. C. TOWNSEND, *Ex'r.*

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7. Interference H.

March 26, 1878.

ROOM No. 118. (No. 14.) (INTERFERENCE.)

INTERFERENCE H.

116–73.
Copy sent
Mar. 26, 1878.
L. S. R.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., M'ch 26, 1878.

ELISHA GRAY, care Baldwin Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your App'n for patent for "Art of Transmitting Vocal Sounds Telegraphically." (Case No. 1) filed Oct. 29, 1877.

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, indorsed on the envelope. The subject-matter involved in the in the interference is: The combination in one circuit of two or more coils of wire, two or more magnets, and two or more discs or diaphragms so arranged relatively to each other, that if one of the discs or diaphragms be put in motion by the voice, by a current of air or otherwise, it shall induce a transient current of electricity in its associated coil, which current shall actuate the other discs or diaphragms in virtue of the coils and magnets associated with them. (Holcombe's 3d claim.)

3857

This is described and shown in applications of Dolbear and Gray, and patent of Bell.

Parties to Interference.

A. G. Holcombe. App'n filed Jan. 28, 1878. Moses G. Farmer, Torpedo Station, Newport, R. I., Att'y of Record.

A. E. Dolbear. App'n filed Oct. 31, 1877. F. L. Pope, Elizabeth, N. J., Att'y of Record. J. L. Norris, Asso. Att'y, Washington, D. C.

A. G. Bell. Patent No. 174,465, dated Mar. 7, 1876. A. Pollok, Washington, D. C., Att'y of Record.

H. C. TOWNSEND. *Ex'r.*

Interference I.

March 26, 1878.

ROOM No. 118. (No. 14.) (INTERFERENCE.)

INTERFERENCE I.

116-73.
Copy made
M'ch 28, '78.
L. S. R.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, M'ch 26th, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your App'n for patent for "Art of Transmitting Vocal Sounds Telegraphically." (No. 1.) Filed Oct. 29, 1877.

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, indorsed on the envelope. The subject-matter involved in the interference is: A telephonic transmitter, consisting of one or more helices, forming a portion of the main circuit and surrounding a core or cores maintained in a magnetic state by the inductive influence, either

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of an electric current or of a permanent magnet in combination with an elastic inductive plate or armature, which is rigidly supported at one or more of its edges, while the portion facing the poles of the magnetic core or cores is left free, so as to be capable of responding to sonorous vibrations traversing the atmosphere or other bodies.

This is substantially Dolbear's 1st claim, and is substantially embraced in Bell's 3d and 8th claims. It is described in applications of Gray and Holcombe.

Parties to Interference.

A. E. Dolbear. App'n filed Oct. 31, 1877. F. L. Pope, Elizabeth, N. J., Att'y of Record. J. L. Norris, Washington, D. C., Asso. Att'y.

A. G. Holcombe. App'n filed Jan. 28, 1878. Moses G. Farmer, Torpedo Station, Newport. R. I., Att'y of Record.

A. G. Bell. Patent No. 186,787, dated Jan. 30, 1877. A. Pollok, Washington, D. C., Att'y of Record.

H. C. TOWNSEND, *Ex'r.*

3856

1877.

Div. 16. Townsend. 116/73

No. No. 1.

Elisha Gray,

Of - - Chicago, - - - - -

County of - - Cook, - - - -

State of - - Illinois. - - - - -

Art or Transmitting Vocal Sounds Telegraphically, &c.

Rec'd, - - - - - Oct. 29, 1877.

Petition, - - - - - " " "

Affidavit, - - - - - " " "

Specification, - - - - - " " "

Drawing, 2 sheets, - - - " " "

Model,

Cert. dep.,

1 Cash, $15, - - - - Oct. 29, 1877.

Add'l Fee Cert.,

" " Cash,

Examined,

2 Issue,

3 Patented, - - - - 187 .

Circular,

Baldwin, Hopkins & Peyton, *Present.*

3857

1877.

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Application, papers.

1. Rej., Oct. 31, 1877.
2. Letter to Office, Dec. 5, '77.
3. " " " " 8, "

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B. 5. Int'f. x $\frac{72}{64}$, $\frac{86}{12}$, $\frac{104}{58}$, $\frac{158}{58}$, Mar. 26, 1878.
F. 6. Int'f. x $\frac{135}{90}$, $\frac{118}{1}$, $\frac{158}{58}$, Mar. 26, 1878.
H. 7. Int'f. x $\frac{135}{90}$, $\frac{118}{1}$, $\frac{158}{58}$, Mar. 26, 1878.
I. 8. Int'f. x $\frac{118}{1}$, $\frac{135}{90}$, $\frac{42}{26}$, Mar. 26, 1878.
9.
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15.
16.
17.
18.

Title:

IMPROVEMENT IN

Ex. M. McK.
M. V.

DEFENDANT'S EXHIBIT, GRAY'S LIQUID TRANSMITTER, SPEAKING TELEPHONE APPLICATION.

(RECORD, PAGE 67.)

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ELISHA GRAY

2 SHEETS Nº 1

APPARATUS FOR TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY.

FILED OCTOBER 29TH 1877

Fig 1

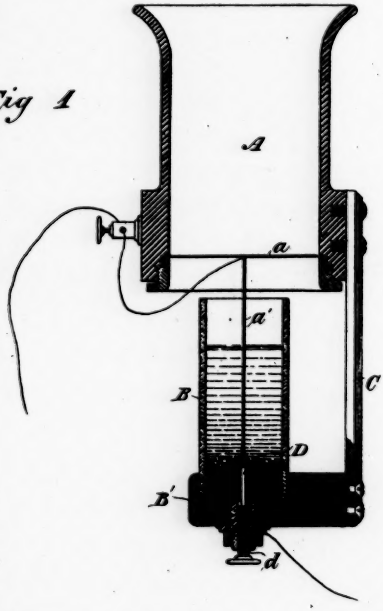


Fig 2.

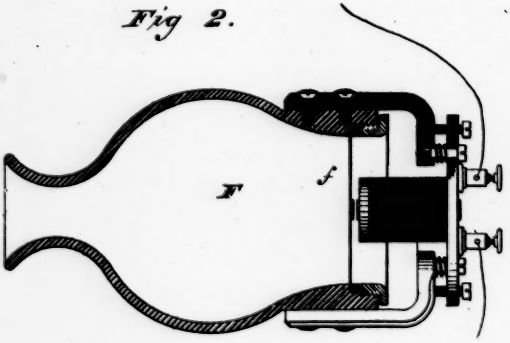
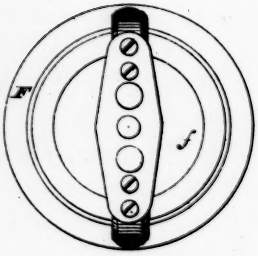


Fig 3.



WITNESSES

Wm A. Skinkle.

INVENTOR

Elisha Gray

By his Attorneys

Baldwin. Hopkins & Peyton

3860

ELISHA GRAY. 2 SHEETS Nº 2

APPARATUS FOR TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY

FILED OCTOBER 29TH 1877

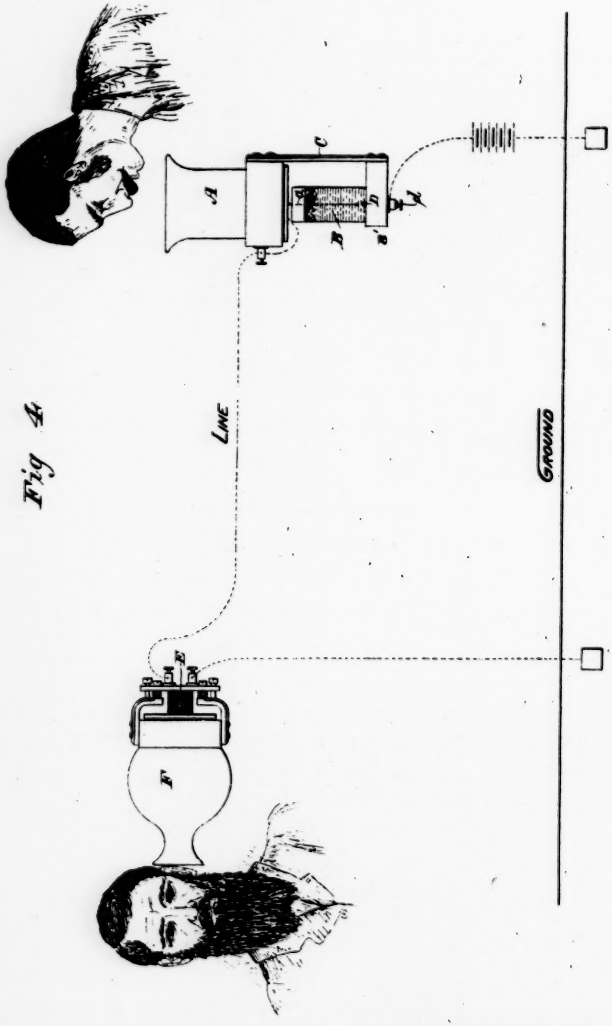


Fig 4

WITNESSES

Wm A. Stinkle.

INVENTOR

Elisha Gray.

By his Attorneys

Baldwin, Hopkins & Peyton.

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Defendant's Exhibit.

"GRAY'S LIQUID TRANSMITTER SPEAKING TELEPHONE APPLICATION."

W. C. W., *Ex'r.*

Department of the Interior,

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the files of this office of the file-wrapper, contents and drawing, in the matter of the application of ELISHA GRAY, filed October 29, 1877, for Apparatus for Transmitting Vocal Sounds Telegraphically.

In testimony whereof, I, W. H. DOOLITTLE, Acting Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this twenty-ninth day of June, in the year of our Lord one thousand eight hundred and seventy-eight, and of the Independence of the United States the one hundred and second.

[L. S.]

W. H. DOOLITTLE,
Acting Commissioner.

Case 2.—Application.

To the Commissioner of Patents:

Your petitioner prays that Letters-Patent may be granted to him for the invention set forth in the annexed specification.

Also, that you will recognize Baldwin, Hopkins & Peyton, his duly authorized attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.

ELISHA GRAY.

To all whom it may concern:

Be it known, that I, ELISHA GRAY, of Chicago, in the County of Cook, and State of Illinois, have invented certain new and useful Improvements in Apparatus for Transmitting Vocal Sounds Telegraphically, of which the following is a specification.

The object of my invention is to transmit tones of the human voice through a telegraphic circuit, and reproduce them at the receiving end of the line, so that actual conversations can be carried on by persons at long distances apart.

My present invention more especially relates to that portion of the telephonic apparatus which takes up the vibrations of the air caused by the utterance of vocal sounds near it, and transmitting them through the circuit to the receiving end of the line, and my purpose is to adapt said apparatus to the accurate reproduction of such sounds as to tone, pitch and quality, which end I attain by interposing in the circuit a varying resistance which adapts itself to all the vibrations which are required to be transmitted through it.

In the accompanying drawings Fig. 1 represents a vertical transverse section through one form of an apparatus embodying my improvements.

Fig. 2 represents a similar section through a receiving apparatus of a different construction, but which is not herein claimed, as it constitutes the subject-matter of another application for Letters-Patent of the United States, filed by me simultaneously herewith.

Fig. 3 an end view of the same.

Fig. 4 represents the transmitter and receiver shown by the preceding figures, as arranged upon circuit.

The transmitter is by preference composed of a box, chamber or tube A, provided with a flaring mouth, though the latter is not essential. Across this chamber is arranged a diaphragm *a* of some thin substance such as parchment or gold-beater skin, capable of responding to all the vibrations of the human voice, whether simple or complex. Attached to this diaphragm is a light metal rod a^1 or other suitable conductor of electricity, which rod extends into a vessel B, of glass or other suitable insulating material, having its bottom closed by a plug, which may be of metal or through which passes a conductor D, forming part of the circuit.

The speaking tube A and base or standard B^1, which latter supports the vessel B, are held in a fixed relation to each other by a

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suitable connecting frame C, or other well known means, and the conductor D above mentioned, is mounted upon an adjusting screw *d*, by which means it may be adjusted very close to the rod, without actual contact. The same result, however, might be attained by adjustably connecting the tube A and standard B^1.

The vibrations of the diaphragm *a* will thus cause the rod a^1 to vary its relation to the conductor D, thus varying the resistance, and consequently the strength of the current passing through the circuit.

It will be observed that the degree of variation in the strength of the electric current will correspond accurately with the amplitude and rapidity of the vibrations of the diaphragm, which vibrations in the enunciation of any given word are variable, both as to amplitude rate and complexity.

The transmitter must, of course, be mounted in a suitable frame, to hold it securely to prevent the waste of the resistance medium where liquid is employed as such medium.

The variations in the strength in the electric circuit thus caused are transmitted through the circuit to the receiving station or reproducing apparatus, in which circuit is included an electro-magnet E of ordinary construction, acting upon a diaphragm *f* in a vocalizing chamber F, the construction of which will be readily understood from the drawings.

Another form of reproducing apparatus is shown in an application for Letters-Patent of the United States, filed by me simultaneously herewith.

What I claim as my invention, and desire to secure by Letters-Patent, is :

1. The transmitter, hereinbefore described, consisting of the combination in an electric circuit, of a diaphragm and a liquid or equivalent substance of high resistance, whereby the vibrations of the diaphragm cause variations in the resistance of the electric circuit, and consequently in the strength of the curent traversing said circuit.

2. The combination, substantially as hereinbefore set forth, in an electric circuit of a diaphragm, a rese[r]voir containing liquid forming part of the circuit, a rod attached to the diaphragm and projecting into the liquid, and an adjustable connection, whereby the paper relation between the parts of the circuit is maintained.

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In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:
WM. J. PEYTON,
WM D. BALDWIN.

DISTRICT OF COLUMBIA, CITY OF WASHINGTON. } *ss:*

ELISHA GRAY, the above-named petitioner, being duly sworn, deposes and says, that he verily believes himself to be the original and first inventor of the Improvements in Apparatus for Trans mitting Vocal Sounds Telegraphically, described in the foregoing specification; that he does not know and does not believe that the same was ever before known or used, and that he is a citizen of the United States.

ELISHA GRAY.

Sworn to and subscribed before me, this 20th day of October, 1877.

[L. S.]

WM. J. PEYTON,
Notary Public.

UNITED STATES
Oct. 29, 1877.
PATENT OFFICE.

WASHINGTON, D. C., Oct. 29, 1877.

U. S. Patent Office.

"TRANSMITTER." (Case 2.)

In the matter of the application of ELISHA GRAY, for Letters-Patent for Apparatus for Transmitting Vocal Sounds Telegraphically, filed Oct. 29, 1877.

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We request that a model may temporarily be dispensed with in the application above mentioned, and that the case be forwarded to the Examiner for his action.

The model will be filed in a few days.

Respectfully,

To the Commissioner of Patents: BALDWIN, HOPKINS & PEYTON, *Att'ys for E. Gray.*

Model can be dispensed with for examination.

J. H. MCDONALD,
Ass't. in Ch'g.

App'd.
W. H. DOOLITTLE,
A. C.

UNITED STATES
Oct. 29, 1877.
PATENT OFFICE.

1. Rejection.

Oct. 31, 1877.

ROOM No. 118.

116–72.
Copy sent
Oct. 31, 1877.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Oct. 31st, 1877.

(Case 2.)

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Telephone or Speaking Telegraph.
Filed Oct. 29, 1877.

The 1st claim of this application is substantially met in patent of A. G. Bell, Mar. 7, 1876, No. 174,465. (Elec. Telephonic Tel'ps.)

The 1st claim is accordingly refused.

H. C. TOWNSEND, *Ex'r.*

2. Letter to Office.

Dec. 4, 1877.

U. S. Patent Office.

In the matter of the application of ELISHA GRAY, for Patent Apparatus for Transmitting Vocal Sounds Telegraphically, filed Oct. 29th, 1877.

WASHINGTON, D. C., Dec. 4, 1877.

To the Commissioner of Patents:

SIR:—Herewith we file a model to complete the above entitled application.

Resp'y,
BALDWIN, HOPKINS & PEYTON,
Att'ys for E. Gray.

PATENT OFFICE,
Dec. 4, 1877,
U. S. A.

---

3. Letter to Office.

Dec. 8, 1877.

U. S. Patent Office.

In the matter of the application of ELISHA GRAY, for Letters-Patent for Improvement in Telephonic or Speaking Telegraph. (Case 2.) Filed October 29th, 1877.

WASHINGTON, D. C., December 8, 1877.

To the Commissioner of Patents:

SIR:

The prompt declaration of an interference with the reference cited in the Official letter of October 31, 1877, is requested, said

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patent being granted in derogation of Gray's Caveat of even date with the application upon which it was granted.

Respectfully,

BALDWIN, HOPKINS & PEYTON,
Atty's for E. Gray.

PATENT OFFICE,
Dec. 8, 1877,
U. S. A.

---

4. Interference C.

Mar. 26, 1878.

ROOM No. 118. (No. 14.) (INTERFERENCE.)
116–72. (No. 2.) INTERFERENCE C.
Copy sent Mch. 26, 1878. L. S. R.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Mar. 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your appl'n filed Dec. 4, '77. (No. 2.)

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the patent and applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, indorsed on the envelope. The subject-matter involved in the interference is .

1st. The transmitter consisting of the combination in an electric circuit of a diaphragm and a liquid or equivalent substance of high resistance, whereby the vibrations of the diaphragm cause variations in the resistance of the electric circuit, and consequently in the strength of current traversing said circuit. (Gray's 1st claim.)

'3868

This is described in applications of Richmond and Edison, and patent of Bell.

2d. In a telegraph instrument operated by sound, the combination with the diaphragm of two or more electrodes placed in electrolytic liquid and operating to increase and decrease the resistance of the electric circuit by the movement derived from the diaphragm. (Edison's 1st claim.)

This is described in the applications of Richmond and Gray, and is substantially suggested in Bell's patent.

The parties to this interference are: G. B. Richmond, App'n filed Aug. 24, '77, G. W. Dyer, Att'y, Washington, D. C. T. A. Edison, App'n filed Sept. 5, '77 (Case 144), L. W. Serrell, Box 4689, N. Y. City, Att'y. A. G. Bell, patent No. 174,465, Mar. 7, '76, A. Pollok, Washington, D. C., Att'y.

H. C. TOWNSEND, *Ex'r.*

---

5. Interference D.

Mar. 26, 1878.

ROOM NO. 118. (No. 14.) (INTERFERENCE.)
116–72.
Copy Mar. 26, 1878.
P. W. P.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C. M'ch. 26, 1878.

INTERFERENCE D.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your appl'n for patent for "Apparatus for Transmitting Vocal Sounds Telegraphically." (Case No. 2) filed Dec. 4. 1877.

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with applications named below, and the question of priority will be determiued in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, indorsed on the envelope. The subject-matter involved in the interference is:

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"In an electro-hydro telephone, the fluid-holding vertically adjustable tube within which the ends of the platinum points are immersed, as set forth substantially in Richmond's 3d claim, described and shown in Edison's application and described in Gray.

Parties to Interference.

Geo. B. Richmond. App'n filed Aug. 24, 1877. George W. Dyer, Washington, D. C., Att'y of Record.

T. A. Edison. App'n filed Sept. 5, 1877. (Case 144.) L. W. Serrell, Box 4689, New York City, Att'y of Record.

H. C. TOWNSEND, *Ex'r.*

3870

1877.

Div. 16. Townsend. $\frac{116}{72}$

No. (No. 2)

Elisha Gray,

Of - - Chicago, - - - -

County of - - Cook, - - -

State of - - Illinois, - - - -

Apparatus for Transmitting Vocal Sounds Telegraphically.

Rec'd, - - - - - Oct. 29, 1877.

Petition, - - - - " " "

Affidavit, - - - - " " "

Specification, - - - " " "

Drawing 2 sheets, - - - " " "

Model, - - - - Dec. 4, 1877.

Cert. Dep.

1 Cash, $15, - - - - Oct. 29, 1877.

Add'l Fee Cert.,

" " Cash,

2 Examined,

Issue,

3 Patented, 187

Circular,

Baldwin, Hopkins & Peyton,
Present.

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1877.

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1. Rej., Oct. 31st, 1877.
2. Letter to Office, Dec. 4, 1877.
3. " " " " 8, "

C. 4. Int'f. x $\frac{104}{58}$, $\frac{107}{15}$, $\frac{158}{58}$, Mar. 26, 1878.

D. 5. Int'f. x $\frac{104}{58}$, $\frac{107}{15}$, Mar. 26, 1878.

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Title:

IMPROVEMENT IN

Ex'd. E. E. McC.

F. F.

3872

DEFENDANT'S EXHIBIT, GRAY'S CONCAVE DIAPHRAGM RECEIVER, SPEAKING TELEPHONE APPLICATION.

(RECORD, PAGE 67.)

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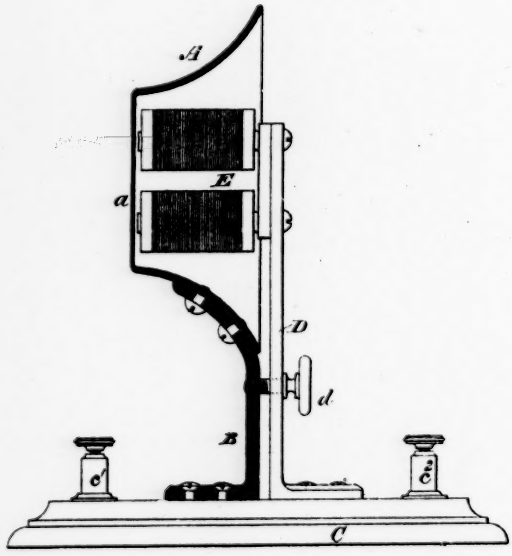
3 Sheets No 1

ELISHA GRAY

IMPROVEMENTS IN ELECTRIC TELEPHONY.

FILED OCTOBER 29TH 1877

Fig 1



WITNESSES

Wm A Brinkle.

Geo W Breck.

INVENTOR

ELISHA GRAY.

By his Attorneys

Baldwin Hopkins & Peyton

3847

3 Sheets No 2

ELISHA GRAY

IMPROVEMENTS IN ELECTRIC TELEPHONY.

FILED OCTOBER 29TH 1877

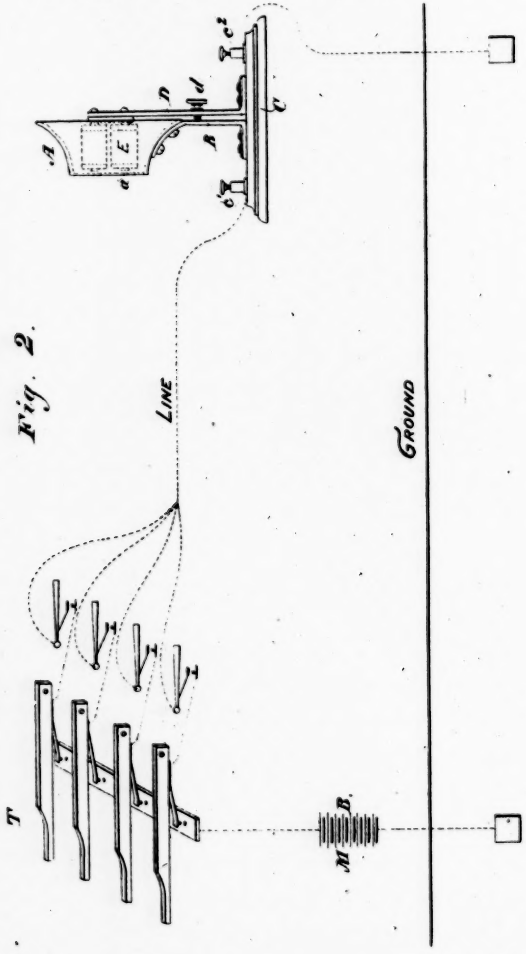


Fig. 2.

WITNESSES

Wm A Skinkle

Geo W Buck

INVENTOR

ELISHA GRAY

By his Attorneys

Baldwin Hopkins & Peyton

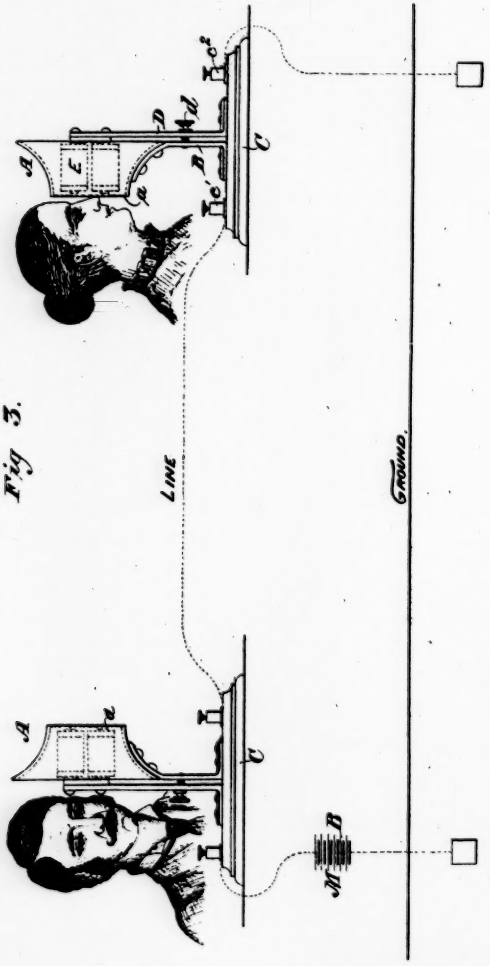
3875

3 Sheets No 3

ELISHA GRAY.

IMPROVEMENTS IN ELECTRIC TELEPHONY.

FILED OCTOBER 29TH 1877



WITNESSES

Wm A. Skinkle.

Geo. H. Buck.

INVENTOR

ELISHA. GRAY.

By his Attorneys

Baldwin, Hopkins & Peyton

3876

Defendant's Exhibit.

"GRAY'S CONCAVE DIAPHRAGM RECEIVER SPEAKING TELEPHONE APPLICATION."

W. C. W., *Ex'r.*

Department of the Interior,

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the files of this office of the file-wrapper, contents and drawing, in the matter of the application of ELISHA GRAY, filed October 29th, 1877, for Electric Telephony.

In testimony whereof, I, ELLIS SPEAR, Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this twenty-first day of [L. S.] August, in the year of our Lord one thousand eight hundred and seventy-eight, and of the Independence of the United States the one hundred and third.

ELLIS SPEAR,
Commissioner.

Case 3.—Application.

To the Commissioner of Patents:

Your petitioner prays that Letters-Patent may be granted to him for the invention set forth in the annexed specification.

Also that you will recognize Baldwin, Hopkins & Peyton, of Washington City, D. C., as his duly authorized attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.

ELISHA GRAY.

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To all whom it may concern :

Be it known, That I, ELISHA GRAY, of Chicago, in the County of Cook, and State of Illinois, have invented certain new and useful Improvements in Electric Telephony, of which the following is a specification :

Letters-Patent of the United States, granted to me on the 27th day of July, 1875, and respectively numbered 166,095 and 166,096, show a method of and apparatus for producing musical tones by the action of a series of vibrating electro-tomes, whereby several musical notes simultaneously can be transmitted over a single electric circuit through a common receiver ; and in an application for Letters-Patent of the United States, filed by me February 23, 1875, I have shown and described an apparatus for analyzing tones thus transmitted at the receiving end of the line, there being a corresponding receiver for each transmitter.

The object of my present invention is to provide an apparatus capable of accurately reproducing in an electric circuit not only the different tones, but the pitch and quality of sounds, whether produced by mechanism or the vocal organs ; to which ends my improvement consists, in interposing in an electric circuit an apparatus consisting essentially of a diaphragm arranged in close proximity to a magnet, so that the diaphragm is rendered sensitive to all electric impulses or vibrations transmitted through the circuit.

In the accompanying drawings,

Figure 1 represents a vertical central section through one form of my improved reproducing apparatus ;

Figure 2 represents an arrangement of the apparatus upon circuit, showing a method of transmitting musical tones produced by vibrating reeds or tuning-forks ;

Figure 3 shows a duplicate arrangement of the reproducing apparatus in the circuit. In this figure either apparatus is capable of reproducing sounds transmitted from the other.

In this instance the reproducing apparatus is represented as consisting of a trumpet-mouth or basin-shaped vessel, A, the bottom of which constitutes a diaphragm of thin sheet-metal, preferably of iron or steel. The vessel is secured by means of screws, or other well-known ways, upon a standard, B, mounted upon a base or frame, C, and electrically connected in well-known ways with the usual binding-posts, c^1 c^2. A post, D, also mounted upon this

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frame, supports a magnet, E, the poles of which approximate closely the diaphragm *a* of the vessel A. The relation of the poles of the magnet to the diaphragm is controlled by means of a set screw, *d*, connecting the posts B and D, or in other well-known ways.

In this instance the magnet is shown as arranged on the inner side of the reproducing vessel A, but it will be equally effective when arranged on the opposite side.

The proper proportion, form and mounting of this plate, disc or diaphragm are important conditions, which must be taken into consideration in order to obtain the best results.

The plate or membrane should be thin—preferably circular—equal in length and breadth, and should be rigidly supported at its edges in a proper frame, while the central portion, being elastic, is left free to take up and respond to sonorous vibrations of every character.

All solid bodies tend to vibrate at a certain definite rate, called the "fundamental," and when shaped with reference to the development of this characteristic to the greatest extent, it is difficult to excite vibration having any degree of amplitude other than the fundamental rate belonging to them respectively. A tuning-fork is an example of a body whose form is calculated to develop this quality in a high degree. On the other hand, the more nearly a body assumes the form of a plate, preferably circular, made thin and supported not at one side alone but all around its edges, the more it loses its special fundamental character and becomes capable of vibrating at one rate as readily as another.

The arrangement of the apparatus upon circuit is shown in Figures 2 and 3, and will readily be understood by reference thereto.

In Figure 2, M B represents the main battery, and T a transmitting apparatus similar to that shown in Letters-Patent No. 179,549, granted to me July 4, 1876, and shows a series of vibrating reeds, each transmitting a musical tone of different pitch, which may be thrown into operation simultaneously or successively by depressing the corresponding keys or levers, all the tones thus produced being transmitted over the line and reproduced by the receiving apparatus above described.

Figure 3 shows the receiver and transmitter both alike.

With an apparatus thus constructed vocal sounds or articulate

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words spoken in one instrument will be accurately reproduced in the other, both as to pitch and quality as well as tone; but I do not broadly claim in this application the transmission of vocal sounds telegraphically, as that forms the subject-matter of another application for Letters-Patent of the United States, filed by me simultaneously herewith.

It will be obvious to a skillful electrician that the details of construction of the reproducing apparatus could be greatly varied without departing from the spirit of my invention, as long as it embodies the arrangement of a diaphragm vibrating in close proximity to but not in contact with a magnet.

What I claim as my invention and desire to secure by Letters-Patent is,

The combination, substantially as hereinbefore set forth, in an electric circuit, of a magnet and a diaphragm supported and arranged in close proximity thereto; whereby sounds thrown upon the line may be reproduced accurately as to tone, pitch and quality.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:
WM. J. PEYTON,
WM. D. BALDWIN.

CITY OF WASHINGTON, }
DISTRICT OF COLUMBIA, } *ss:*

ELISHA GRAY, the above-named petitioner, being duly sworn, deposes and says that he verily believes himself to be the original and first inventor of the Improvement in Electric Telephony, described in the foregoing specification; that he does not know and does not believe that the same was ever before known or used, and that he is a citizen of the United States.

ELISHA GRAY.

Sworn to and subscribed before me this 20th day of October, 1877.

[L. S.] WM J. PEYTON,
Notary Public.

UNITED STATES PATENT OFFICE, Oct. 29, 1877.

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WASHINGTON, D. C., Oct. 29, 1877.

U. S. Patent Office.

"REPRODUCER." (Case 3.)

In the matter of the application of ELISHA GRAY for Letters-Patent for Improvement in Electric Telephony, filed Oct. 29, 1877.

We request that a model may temporarily be dispensed with in the application above mentioned, and that the case be forwarded to the Examiner for his action.

The model will be filed in a few days.

Respectfully,
BALDWIN, HOPKINS & PEYTON,
Att'ys for E. Gray.

To the Commissioner of Patents:

Model can be dispensed with for examination.

J. H. MCDONALD,
Ass't in Ch'g.

App'd.
W. H. DOOLITTLE, *A. C.*

UNITED STATES PATENT OFFICE, Oct. 29, 1877.

---

1. Rejection.

Oct. 31, 1877.

ROOM NO. 118. DEPARTMENT OF THE INTERIOR, UNITED STATES PATENT OFFICE, WASHINGTON, D. C., Oct. 31, 1877.

Copy sent
Oct. 31, 1877.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

ELECTRIC TELEPHONY. Filed Oct. 29, 1877.

The peculiarities of "magnet" F and its operation in connection with the diaphragm are not set forth with sufficient fullness. Said magnet is not described or shown as being in any manner different from the ordinary electro-magnet having soft iron core and surrounding coils.

The application however appears to be fully met in patent of A. G. Bell, Jan'y 30, 1877, No. 186,787 (Elec. Telephonic Tel'hs.) The application is accordingly refused.

H. C. TOWNSEND, *Ex'r.*

2. Letter to Office.

Dec. 4, 1877.

U. S. Patent Office.

In the matter of the application of ELISHA GRAY for Patent for Electric Telephony, filed Oct. 29, 1877.

WASHINGTON, D. C., Dec. 4, 1877.

To the Commissioner of Patents:

SIR: Herewith we file a model to complete the above-entitled application.

Resp'y,

BALDWIN, HOPKINS & PEYTON,
Att'ys for Elisha Gray.

U. S.
PATENT OFFICE,
Dec. 4, 1877.

3. Letter to Office.

Dec. 8, 1877.

U. S. Patent Office.

In the matter of the application of ELISHA GRAY for Letters-Patent for Electric Telephony, filed Oct. 29, 1877. (Case 3.)

WASHINGTON, D. C., Dec. 8, 1877.

To the Commissioner of Patents:

SIR: We have the Official Letter of October 31, 1877. An interference is requested with the reference cited, which patent was allowed and issued in direct violation of Gray's Caveat, filed eleven months previously and in full force and effect when said patent was granted; and as the attention of the Office had been specially called to this Caveat at the time of the filing of the application for Bell's patent of March 7, 1876, we are at a loss to understand how it could have been so completely ignored by the

Office. By such action great injustice has been done to our client and his interests materially affected.

It being unnecessary for the purposes of this application that the construction and operation of the magnet with reference to the diaphragm should differ from its heretofore well-known operation in connection with other forms of armature, it was deemed unnecessary to describe its operation more fully, as it is well known to all skillful electricians; but such explanation will be furnished if required.

The error of the Office appears to have arisen from the assumption that an electro-magnet with a soft iron core would not act inductively.

The misapprehension may have been caused by overlooking the fact that Gray uses a battery and a closed circuit, consequently the magnet is permanently charged.

Respectfully,
BALDWIN, HOPKINS & PEYTON,
Att'ys for E. Gray.

U. S.
PATENT OFFICE,
Dec. 8, 1877.

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4. [Office] Letter.

Mar. 18, '78.

Copied Mar. 18, 1878.

ROOM No. 118. Case No. 3.

116-71. DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., Mar. 18, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

ELECTRIC TELEPHONY. Filed Oct. 29, 1871.

On further consideration of this case with a view to the declaration of an interference involving patent of Bell and other pending applications, it appears that by inadvertence the patent of Bell, No. 186,787, was cited in official letter of Oct. 31, 1877, as an anticipation, when in fact the claim as drawn should have been rejected, on reference to patent of Bell, No. 174,465. It is true that applicant describes the diaphragm explicitly as a "metal"

diaphragm, but he also incidentally speaks of a "plate or membrane," so that by implication the diaphragm might possibly be said to be either of metal or of some membraneous material with an armature attached, although such a construction is nowhere specifically described or shown.

In an application filed subsequently to the present it is explicitly stated that the diaphragm has an armature attached or that the diaphragm may itself be metallic and constitute the armature, and based on this description is a claim in the same terms as applicant's, which claim, viewed in the light of the specification, was necessarily rejected on the patent of Bell, No. 174,465. If the claim in the present application is to be construed so broadly as to include a membraneous diaphragm, it should obviously be also rejected upon Bell's patent, No. 174,465; but if it is the intention to limit the application to a "metallic diaphragm," such limitation should be expressed in the claim by the use of the word metallic, and reference in the specification either specifically or impliedly to a "membraneous" diaphragm should be omitted.

As the matter now stands, the Office is in doubt as to the exact scope of the specification and claim.

H. C. TOWNSEND, *Ex'r.*

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5. Letter to Office.

Mar. 20, 1878.

United States Patent Office.

In the matter of the application of ELISHA GRAY for Electric Telephony, filed October 29, 1877.

WASHINGTON, D. C., March 20, 1878.

To the Commissioner of Patents:

SIR: Referring to the Official letter of the 18th inst., we request that Bell's patent, No. 174,465, may be included in the Interference if there is anything in said patent relative to a Talking Telephone, as it is our client's intention to contest the matter in its broadest scope.

Respectfully,
BALDWIN, HOPKINS & PEYTON,
Att'ys for E. Gray.

U. S.
PATENT OFFICE,
Mar. 20, 1878.

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6. Interference E.

M'ch 26, '78.

ROOM No. 118. (No. 14.) (INTERFERENCE.)

$\frac{116}{71}$ (No. 3.) INTERFERENCE E.

Copy sent Mar. 26, 1878. L. S. R.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., March 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your Application, filed Dec. 4, '77—Electric Telephony.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it endorsed on the envelope. The subject-matter involved in the interference is in an acoustic telegraph, an armature plate, the electro-magnet for the same, and a closed circuit passing from the helix of such electro-magnet to the source of undulatory electric energy.

This is the subject-matter of Edison's 3d claim, and is substantially described in the other applications and the patent involved.

The parties to this interference are:

T. A. Edison, app'n filed Dec. 13, '77 (Case 145), L. W. Serrell, Box 4689, N. Y. City, Attorney.

A. E. Dolbear, app'n filed Oct. 31, '77, F. L. Pope, Elizabeth, N. J., Att'y of Record; Jas. L. Norris, of Washington, D. C., associate.

A. G. Holcombe, app'n filed Jan. 28, '78, M. G. Farmer, Torpedo Station, Newport, R. I., Att'y.

A. G. Bell, patent No. 174,465, March 7, '76, A. Pollok, Washington, D. C., Att'y.

Geo. B. Richmond, app'n filed Aug. 24, '77, G. W. Dyer, Washington, D. C., Att'y.

H. C. TOWNSEND, *Ex'r.*

7. Interference G.

M'ch 26, 1878.

ROOM No. 118. (No. 14.) (INTERFERENCE.)

116-71 INTERFERENCE G.

Copy sent M'ch 26. L. S. R.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., M'ch 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your app'n for patent for "Electric Telephony," filed Dec. 4, 1877 (Case No. 3).

Very respectfully,

INTERFERENCE G.

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject-matter involved in the interference is "A telephonic receiver consisting of the combination in an electric circuit of a magnet and a diaphragm supported and arranged in close proximity thereto, whereby sounds thrown upon the line may be reproduced accurately as to pitch and quality" (substantially Gray's claim).

This is substantially covered by Holcombe's 2d claim, and is described or shown in the applications of Richmond, Dolbear, Edison, and McDonough, and in patent of Bell.

PARTIES TO INTERFERENCE:

Elisha Gray, app'n filed Dec. 4, 1877 (No. 3), Baldwin, Hopkins & Peyton, Washington, D. C., Att'ys of Record.

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Geo. B. Richmond, app'n filed Aug. 24, 1877, G. W. Dyer, Washington, D. C., Att'y of Record.

A. E. Dolbear, app'n filed Oct. 31, 1877, F. L. Pope, Elizabeth, N. J., Att'y of Record, J. L. Norris, Washington, D. C., Asso. Att'y.

T. A. Edison, app'n filed Dec. 24, 1877 (No. 148), L. W. Serrell, Box 4689, New York City, Att'y of Record.

A. G. Holcombe, app'n filed Jan'y 28, 1878, Moses G. Farmer, Torpedo Station, Newport, R. I., Att'y of Record.

James W. McDonough, app'n filed April 10, 1876, Gridley & Sherburne, Chicago, Ill., Atty's of Record.

A. G. Bell, Patent No. 174,465, dated Mar. 7, 1876, A. Pollok, Washington, D. C., Att'y of Record.

H. C. TOWNSEND, *Ex'r.*

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8. Interference J.

Mar. 26, 1878.

ROOM No. 118. (No. 14.) (INTERFERENCE.)

$\frac{116}{71}$ (No. 3.)

INTERFERENCE J.

Copy made M'ch 28, 1878.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., March 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your application filed Dec. 4, '77—Electric Telephony.

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject-matter involved in the inter-

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ference is: The combination with an electro-magnet of an iron or steel diaphragm secured to a resonant case for rendering audible acoustic vibrations. (Edison's 1st Claim.) This is substantially embraced in Bell's 3d and Dolbear's 3d claims, and described in app'ns of the remaining parties.

The parties to this interference are.

T. A. Edison, app'n filed Dec. 24, '77 (Case 148), L. W. Serrell, Box 4689, N. Y. City, Attorney.

G. B. Richmond, app'n filed Aug. 24, '77, G. W. Dyer, Washington, D. C., Att'y.

A. E. Dolbear, app'n filed Oct. 31, 1877, F. L. Pope, Elizabeth, N. J., Att'y, and J. L. Norris, Washington, D. C., associate.

A. G. Holcombe, app'n filed Jan. 28, '78, M. G. Farmer, Torpedo Station, Newport, R. I., Att'y.

A. G. Bell, Patent No. 186,787, Jan. 30, '77, A. Pollok, Washington, D. C., Att'y.

H. C. TOWNSEND, *Ex'r.*

3886

1877.

DIV. 16. TOWNSEND. 116/71

No. No. 3.

ELISHA GRAY,

Of - - Chicago, - - - - -

County of - - Cook, - - -

State of - - Illinois. - - - -

ELECTRIC TELEPHONY.

Rec'd, - - - - - Oct. 29, 1877.

Petition, - - - - - " " "

Affidavit, - - - - - " " "

Specification, - - - - - " " "

Drawing, 3 sheets, - - - " " "

Model, - - - - - Dec. 4, "

Cert. dep.,

1 Cash, $15, - - - - Oct. 29, 1877.

Add'l Fee Cert.,

" " Cash,

2 Examined,

Issue,

3 Patented, - - - - 187 .

Circular,

BALDWIN, HOPKINS & PEYTON, *Present.*

3889

1877.

CONTENTS.

Application, papers.
1. Rej., Oct. 31, 1877.
2. Letter to Office, Dec. 4, '77.
3. Letter to Office, Dec. 8, 1877.
4. Letter, - Mar. 18, 1878.
5. " to Office, Mar. 20, '78.

E. 6. Int'f. x $\frac{126}{48}$, $\frac{118}{11}$, $\frac{104}{58}$, $\frac{135}{90}$, $\frac{158}{58}$, Mar. 26, '78.

G. 7. Int'f. x $\frac{104}{58}$, $\frac{118}{1}$, $\frac{128}{58}$, $\frac{135}{90}$, $\frac{176}{32}$, $\frac{158}{58}$, Mar. 26, 1878.

J. 8. Int'f. x $\frac{128}{85}$, $\frac{104}{58}$, $\frac{118}{1}$, $\frac{135}{90}$, $\frac{42}{26}$, Mar. 26, 1878.

9.
10.
11.
12.
13.
14.
15.
16.
17.
18.

36. ELECTRICITY. Telephonic Telegraphs.

Title:

IMPROVEMENT IN

Ex. S. P. P.
M. McK.

781

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DEFENDANT'S EXHIBITS.

ILLUSTRATIONS.

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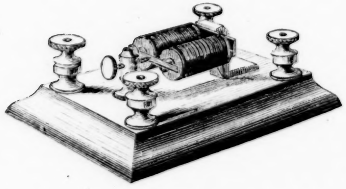
DEFENDANT'S EXHIBIT, GRAY'S FIRST SINGLE TONE TRANSMITTER.

(RECORD, PAGE 71.)



DIMENSIONS.

Length of spool	$1\frac{1}{2}$ inches.
Diameter of spool	$\frac{3}{4}$ "
Length of core	$1\frac{7}{8}$ "
Diameter of core	$\frac{1}{4}$ "

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DEFENDANT'S EXHIBIT, ANIMAL TISSUE VIOLIN RECEIVER.

(Record, Page 72.)

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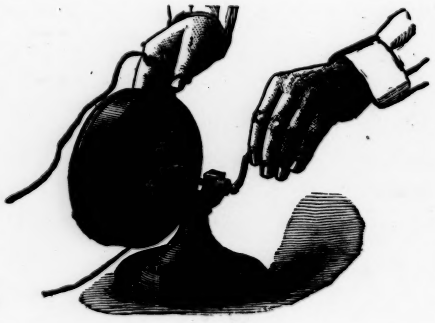
DEFENDANT'S EXHIBIT, GRAY'S ANIMAL TISSUE REVOLVING PLATE RECEIVER.

(RECORD, PAGE 72.)



DIMENSIONS.

Diameter of drum	. . . . .	$7\frac{1}{4}$ inches.
Thickness of drum	. . . . .	$2\frac{3}{8}$ "

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DEFENDANT'S EXHIBIT, PAPER DRUM RECEIVER.

(RECORD, PAGE 74.)

DIMENSIONS.

Diameter of drum	$3\frac{3}{8}$ inches.
Thickness of "	1 "

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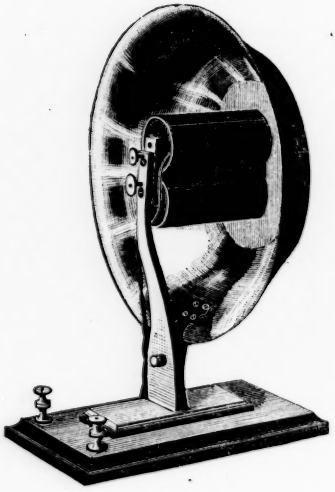
DEFENDANT'S EXHIBIT, GRAY'S CONCAVE METALLIC DIAPHRAGM MAGNET RECEIVER.

(RECORD, PAGE 77.)



DIMENSIONS.

Diameter of concave diaphragm . . .	11 inches.
Diameter of base of diaphragm . . .	$5\frac{3}{4}$ "
Diameter of spool	$1\frac{3}{4}$ "
Diameter of core	$\frac{3}{8}$ "
Length of core	$3\frac{3}{8}$ "

3896

DEFENDANT'S EXHIBIT, GRAY'S TWO-OCTAVE TRANSMITTER.

(RECORD, PAGE 78.)

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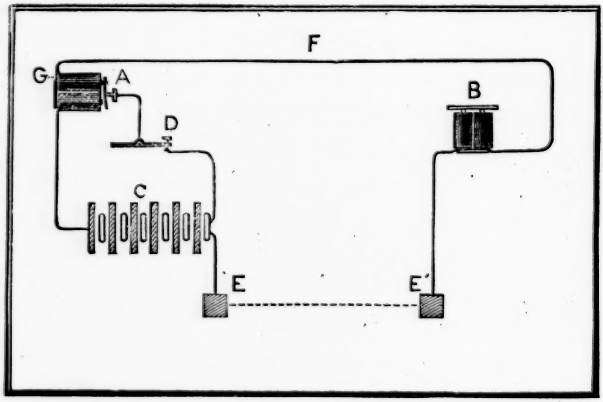
DEFENDANT'S EXHIBIT, GRAY'S CLOSED CIRCUIT SINGLE TONE TRANSMISSION APPARATUS.

(RECORD, PAGE 85.)



A Single Tone Transmitter.
B Magnet Receiver.
C Battery.
D Key in Short Circuit.
E E' Ground Connection.
F Line Wire.

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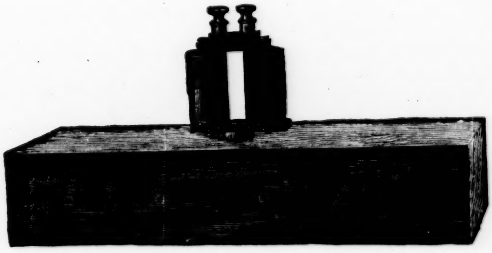
DEFENDANT'S EXHIBIT, GRAY'S WOODEN SOUNDING BOX MAGNET RECEIVER.

(RECORD, PAGE 87.)



DIMENSIONS.

Length of box	$16\frac{1}{4}$	inches.
Length of spool	$2\frac{1}{2}$	"
Diameter of spool	$1\frac{1}{4}$	"

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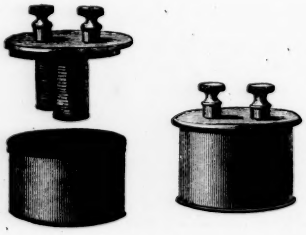
DEFENDANT'S EXHIBIT, DIAPHRAGM BOX MAGNET RECEIVER.

(RECORD, PAGE 88.)



DIMENSIONS.

Length of core	$1\frac{1}{2}$ inches.
Diameter of core	$\frac{1}{4}$ "
Diameter of cup	3 "
Height of cup	$2\frac{1}{8}$ "

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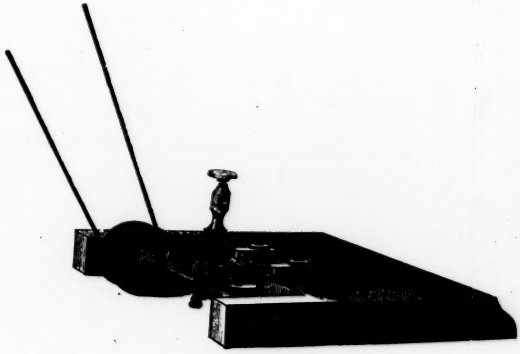
DEFENDANT'S EXHIBIT, GRAY'S MECHANICAL TRANSMITTER.

(RECORD, PAGE 108.)



DIMENSIONS.

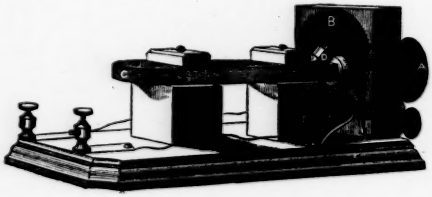
Length of shaft . . . . . $5\frac{1}{8}$ inches.

772

3901

DEFENDANT'S EXHIBIT, BELL TELEPHONE A.
(Interior View.)

(RECORD, PAGE 268.)



A Speaking Tube.
B Metallic Diaphragm.
C Permanent Magnet.
D Signal Call.

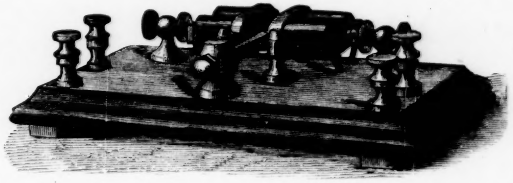
DIMENSIONS.

Length of permanent magnet . . .	$7\frac{1}{4}$	inches.
Length of spool	$\frac{3}{8}$	"
Diameter of spool	$1\frac{1}{8}$	"
Diameter of diaphragm	$4\frac{1}{4}$	"
Length of speaking tube	$3\frac{1}{4}$	"

3902

DEFENDANT'S EXHIBIT, GRAY'S MULTIPLE TRANSMITTER OF 1875.

(RECORD, PAGE 270.)



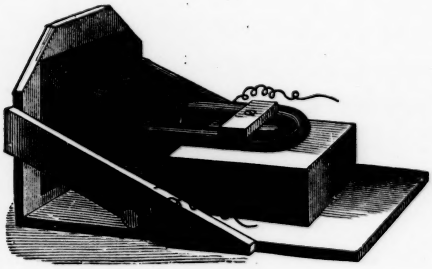
DIMENSIONS.

Length of spool	$1\frac{1}{2}$ inches.
Diameter of spool	$\frac{7}{8}$ "
Diameter of core	$\frac{1}{4}$ "
Length of core	$1\frac{5}{8}$ "
Length of reed	$3\frac{1}{4}$ "

3903

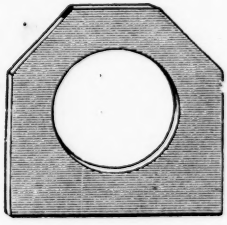
DEFENDANT'S EXHIBIT, DOLBEAR TELEPHONE.

(RECORD, PAGE 291.)



DIMENSIONS.

Length of magnet	6	inches.
Diameter of magnet	$\frac{1}{2}$	"
Length of spools	$2\frac{1}{2}$	"
Diameter of spools	$1\frac{5}{8}$	"



Diameter of aperture	$1\frac{1}{4}$	inches.

DEFENDANT'S EXHIBIT, GRAY'S TWO-TONE TRANSMITTER.

(RECORD, PAGE 69.)

This instrument is shown in various views in the drawings of defendant's Exhibit Johnson Patent, Gray's Magnet Receiver. Part II., page 566.

DEFENDANT'S EXHIBIT, TIN PLATE RECEIVER.

(RECORD, PAGE 70.)

This is an ordinary tin plate about nine inches in diameter, having a screw cup attachment.

DEFENDANT'S EXHIBIT, GRAY'S RESONANT BOX MAGNET RECEIVER.

(RECORD, PAGE 74.)

This is a hollow circular tin box with holes in the top, and is about three and one half inches in diameter and one inch in height. It is shown, resting on the poles of an electro-magnet, on sheet 1 of the drawings of defendant's Exhibit Gray Magnet Receiver Patent, Part II., page 579.

DEFENDANT'S EXHIBIT, BELL AND PATENT OFFICE CORRESPONDENCE.

(RECORD, PAGE 156.)

This correspondence may be found in complainants' Exhibit No. 36, Bell's Application of 1876. Part II., pages 56 to 61 inclusive.

DEFENDANT'S EXHIBITS, BELL APPARATUS OF 1876 PATENT, TRANSMITTER, AND BELL APPARATUS OF 1876 PATENT, RECEIVER.

(RECORD, PAGE 204.)

These are instruments constructed in conformity with the specification and drawings of the Bell patent of March 7, 1876; and the complainants' Exhibits Nos. 15 and 16, Part II., following page 49, are respectively close copies.

3905

DEFENDANTS' EXHIBIT, BELL APPARATUS OF 1876 PATENT, ALTERNATIVE ARMATURES.

(RECORD, PAGE 204.)

These are lighter and heavier armatures than the ones on the defendant's Exhibits Bell Apparatus of 1876 Patent, Transmitter and Receiver, and adapted to be substituted for them.

DEFENDANT'S EXHIBIT, BELL TELEPHONE B.

(RECORD, PAGE 268.)

This instrument is what is known as a magneto-box telephone. The magnet employed is a compound horseshoe magnet, with soft iron cores attached to each pole. The length of the coils upon these cores is about three eighths of an inch, and the diameter of the diaphragm is about three and seven eighths inches.

DEFENDANT'S EXHIBIT, DOLBEAR DIAGRAM OF SEPTEMBER 20, 1876, J. H. T., SPECIAL EXAMINER.

(RECORD, PAGE 288.)